EXPERIMENTS WITH WHEAT
AT THE
DOMINION EXPERIMENTAL FARM
BRANDON, MANITOBA

A SUMMARY 1889—1923

By W. C. McKILLICAN, B.S.A.
SUPERINTENDENT AT BRANDON

Marquis wheat following corn in crop rotation.

DOMINION OF CANADA
DEPARTMENT OF AGRICULTURE
BULLETIN No. 42.—NEW SERIES

Experimental Farms Branch
E. S. ARCHIBALD, B.A., B.S.A., Director.

Published by direction of the Hon. W. R. Motherwell, Minister of Agriculture,
Ottawa, 1924

DOMINION EXPERIMENTAL FARMS BRANCH

PERSONNEL

DIRECTOR, E. S. ARCHIBALD, B.A., B.S.A.

Dominion Field Husbandman..... E. S. Hopkins, B.S.A., M.S.
Dominion Chemist..... Frank T. Shutt, M.A., D.Sc.
Dominion Horticulturist..... W. T. Macoun.
Dominion Cerealist..... L. H. Newman, B.S.A.
Dominion Botanist..... H. T. Güssow.
Dominion Animal Husbandman..... G. B. Rothwell, B.S.A.
Dominion Forage Crop Specialist..... G. P. McRostie, B.S.A., Ph.D.
Dominion Poultry Husbandman..... F. C. Elford.
Dominion Tobacco Husbandman..... C. M. Slagg, M.A., B.S.
Dominion Apiarist..... C. B. Gooderham, B.S.A.
Dominion Bacteriologist..... Grant Lochhead, Ph.D.
Chief Officer, Extension and Publicity..... F. C. Nunnick, B.S.A.
Chief Supervisor of Illustration Stations..... John Fixter.
Economic Fibre Specialist..... R. J. Hutchinson.

ALBERTA

Superintendent, Experimental Station, Lacombe, Alta., F. H. Reed, B.S.A.
Superintendent, Experimental Station, Lethbridge, Alta., W. H. Fairfield, M.Sc.
Superintendent, Experimental Sub-station, Beaverlodge, Alta., W. D. Albright.
Superintendent, Experimental Sub-station, Fort Vermilion, Alta., Robt. Jones.

BRITISH COLUMBIA

Superintendent, Experimental Farm, Agassiz, B.C., W. H. Hicks, B.S.A.
Superintendent, Experimental Station, Summerland, B.C., W. T. Hunter, B.S.A.
Superintendent, Experimental Station, Invermere, B.C., R.G. Newton, B.S.A.
Superintendent, Experimental Station, Sidney, B.C., E. M. Straight, B.S.A.

MANITOBA

Superintendent, Experimental Farm, Brandon, Man., M. J. Tinline, B.S.A.
Superintendent, Experimental Station, Morden, Man., W. R. Leslie, B.S.A.

SASKATCHEWAN

Superintendent, Experimental Farm, Indian Head, Sask., W. H. Gibson, B.S.A.
Superintendent, Experimental Station, Rosthern, Sask., W. A. Munro, B.A., B.S.A.
Superintendent, Experimental Station, Scott, Sask., Victor Matthews, B.S.A.
Superintendent, Experimental Station, Swift Current, Sask., J. G. Taggart, B.S.A.

NEW BRUNSWICK

Superintendent, Experimental Station, Fredericton, N.B., C. F. Bailey, B.S.A.

NOVA SCOTIA

Superintendent, Experimental Farm, Nappan, N.S., W. W. Baird, B.S.A.
Superintendent, Experimental Station, Kentville, N.S., W. S. Blair.

PRINCE EDWARD ISLAND

Superintendent, Experimental Station, Charlottetown, P.E.I., J. A. Clark, B.S.A.

ONTARIO

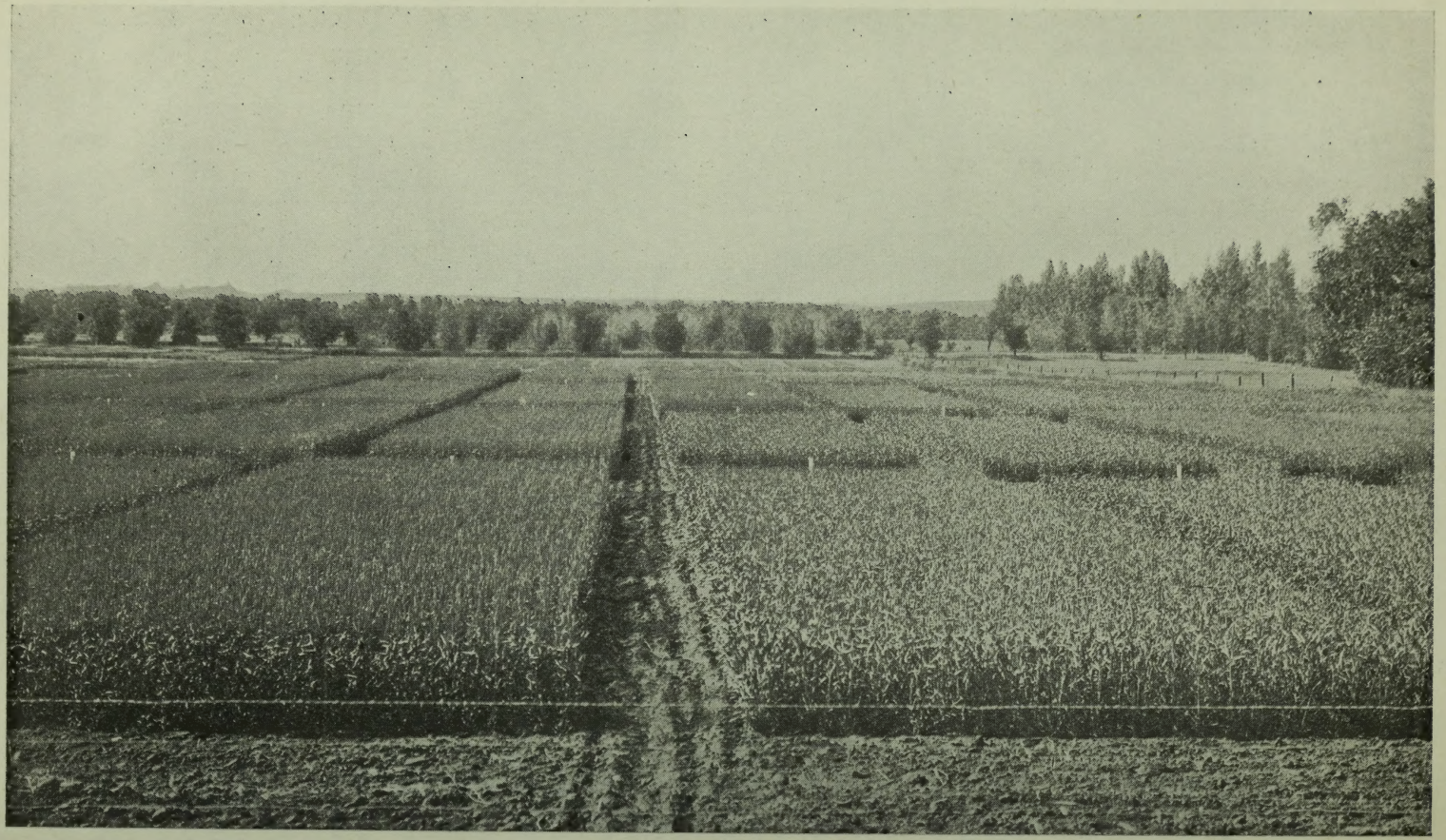
Central Experimental Farm, Ottawa, Ont.
Superintendent, Experimental Station, Kapuskasing, Ont., S. Ballantyne
Superintendent, Experimental Station, Harrow, Ont., D. D. Digges, B.S.A., M.S.A.

QUEBEC

Superintendent, Experimental Station, Cap Rouge, Que., G. A. Langelier, D.Sc.A.
Superintendent, Experimental Station, Lennoxville, Que., J. A. McClary.
Superintendent, Experimental Station, Ste. Anne de la Pocatière, Que., J. A. Ste. Marie, B.S.A.
Superintendent, Experimental Station, La Ferme, Que., P. Fortier, Agr.
Superintendent, Tobacco Experimental Station, Farnham, Que., J. E. Montreuil, B.S.A.

TABLE OF CONTENTS

86999—1



General view of variety test plots of wheat. Taken on June 26 when early varieties are beginning to head.

EXPERIMENTS WITH WHEAT

AT THE DOMINION EXPERIMENTAL FARM, BRANDON

A SUMMARY, 1889-1923

BY W. C. McKILLICAN, B.S.A.

INTRODUCTORY

The growing of wheat has been the principal business of Manitoba ever since this province passed from the fur trading stage and developed into an agricultural section. The soil and climate are particularly suited to the production of wheat of unusually good quality and high yield. While recent events tend to indicate that too much reliance has been put upon wheat alone, it is still Manitoba's most important crop.

It has, therefore, been the duty of an Experimental Farm serving such a province to conduct experiments with wheat in order to find and prove varieties suitable for the soil and climate and to determine the best methods of preparing the soil and handling the crop so as to get the most profitable results. As much of the work that has been done in the past is in danger of being forgotten, and its value lost, it is the purpose of the writer to bring together in this bulletin in concise form a summary of the experimental work done with wheat by his predecessors and by himself and assistants.

TESTS OF VARIETIES

The testing of varieties has always been an important feature of Experimental Farm work. Variety tests were started at Brandon in 1889, the first year after the Farm started. The first test included the varieties commonly grown in the West. Among these, by far the most important, was Red Fife. As the result of these tests, and of the general experience of western farmers and the handlers of western grain, it became the variety almost exclusively grown in Manitoba for many years. Other varieties which showed themselves to be of merit at that early time and were grown to some extent, were White Fife and Red Fern. The other varieties commonly in use in the early days were quickly shown to be inferior.

In the 1889 tests were included quite a number of varieties from other countries that grew hard spring wheat. The late Dr. Wm. Saunders, then Director of Experimental Farms, made a thorough search of such countries for varieties which might be suitable to our climate, produce wheat of good milling quality and ripen earlier than the varieties then in use. Russia and India especially were drawn upon for varieties to be tested. This importation of varieties was conducted chiefly from 1889 to 1893. None of the varieties thus introduced proved to be of sufficient merit to win for themselves any prominent place in the wheat growing of Manitoba, and they were all gradually dropped from the test list of the Brandon Farm. However, two of them have indirectly been of great importance through the cross-bred varieties of which they were parents. These were Ladoga, imported from Russia, and Hard Red Calcutta, imported from India, both of which appear in the 1889 test list at Brandon. From 1892 to 1899, the great majority of the new kinds of wheat introduced into the test were cross-bred varieties originated by Dr.

Wm. Saunders and those associated with him at the Central Farm, Ottawa. The object of this crossing was to combine the milling quality of Red Fife, White Fife, or one of the other wheats of high quality with the earliness of some of the Russian or Indian varieties which had been imported. A large number of these new cross-breds were sent to Brandon, as well as to the other branch farms, for practical try-outs. They were gradually eliminated for one fault or another until four stood out as the most valuable. These were Preston, Percy, Huron, and Stanley. Of these Preston probably achieved the greatest popularity and was quite widely grown throughout the northern parts of the Prairie Provinces for many years. However, it was not equal to Red Fife as a milling wheat, and never secured the goodwill of the milling interests.

Head of Marquis Ottawa 15.

In 1908 Marquis was first included in the Brandon trials. The introduction of this variety was an epoch-making event for western wheat growing. It was the result of a cross between Red Fife and the Indian wheat, Hard Red Calcutta, previously referred to. This variety was isolated from a large amount of other cross-bred material by Dr. C. E. Saunders who for many years was Dominion Cerealist. He selected a pure strain of highly desirable qualities, subjected it to milling and baking tests, and sent it to the branch Farms for field trials. Its introduction has changed the whole western wheat crop, for instead of Red Fife being grown almost exclusively as it was until about 1910 or 1911, now it has practically disappeared and Marquis is grown more widely than Red Fife ever was.

Since 1908 such new varieties as were introduced by plant breeders or seedsmen and that seemed at all promising have been included in these tests. Some of these are excellent varieties, but a new sort must show itself equal to the best standard variety in every particular and its superior in one or more particulars. From this standpoint, none of the introductions of recent years have been able to oust Marquis from its general commanding position, though some are proving valuable for special conditions in limited areas.

Heads of Red Fife wheat.

The following table gives a list of the varieties of spring wheat tested at Brandon from 1889 to 1923, the date upon which each was added to the list, the date when each was dropped and the reason for dropping so far as known. Those for which no date is given for dropping from the test are still included in the trials.

VARIETY TESTS OF SPRING WHEAT, 1889–1923

Variety	Date first tested	Date dropped from test	Why dropped from test
A No. 1	1893	1893	Low yield.
Abundance	1893	1893	Low yield.
Acme	1922	....	
Admiral	1895	1904	Not as valuable as Preston.
Advance	1894	1905	Not as valuable as Preston.
Albert	1893	1893	Poor quality.
Alpha	1892 1895	1893 1903	Low yield. Not as valuable as Preston.
Anglo-Canadian	1893	1893	Low yield; badly rusted.
Angus	1901	1903	Not as valuable as Preston.
Arnautka	1922	....	
Assiniboine	1890	1890	Low yield.
Australian	1891	1892	Rusts badly.
Australian No. 9	1901	1905	Not as valuable as Red Fife.
Australian No. 10	1901	1903	Rusts badly; low yield.
Australian No. 13	1901	1903	Low yield.
Australian No. 19	1901	1904	Rusts badly; late.
Australian No. 23	1901	1903	Rusts badly; low yield.
Australian No. 25	1901	1903	Rusts badly; low yield.
Australian No. 27	1901	1903	Rusts badly; low yield.
Azima	1893	1893	Late.
Bearded Red	1892	1892	Low yield.
Beaudry	1895	1902	Rust.
Beauty	1896	1902	
Benton	1901	1904	Not as valuable as Preston.
Beta	1892	1893	Low yield.
Bishop	1901 1905	1903 1911	Rust. Displaced by Marquis.
Black Sea	1892	1899	Not equal to Red Fife in milling quality.
Blair	1898	1903	Low yield; late.
Blenheim	1894	1902	Not as valuable as Preston.
Blue Stem	1890	1892	Subject to rust; very late.
Burbank Quality	1922	....	
Byron	1899	1904	
California White	1889	1890	Soft.
Campbell's Triumph	1890	1893	Low yield.
Campbell's White Chaff	1890	1902	Soft, not as productive as Fife.
Captor	1894	1902	Rust; medium yield.
Carleton	1892	1893	Low yield.
Carter's F	1892	1892	Weak straw; late.
Carter's Selection D	1890	1890	Very late.
Carter's Selection I	1890	1892	Rust.
Cartier	1901	1903	Not as valuable as Preston.
Cassell	1901	1903	Rust.
Chelsea	1908	1910	Not as valuable as Marquis.
Chester	1901	1905	Rust.
Chilian White	1890	1892	Low yield.
Club	1889 1899	1892 1899	Very subject to smut. Rust; very low milling quality.
Club Bombay	1890	1892	Low yield.
Club Calcutta	1890	1890	
Clyde	1899	1905	Not as valuable as Preston.
Colorado	1890	1907	Rusts badly; inferior milling quality.
Countess	1896	1905	Rust.
Crawford	1899	1904	Not as valuable as Preston.
Criddle's Red Fife	1920	1922	Late, rust.
Criddle's Marquis	1921	....	
Crown	1893	1903	Not as valuable as Preston.
Crown (Ottawa 353)	1917	....	
Dawn	1896	1905	Not as valuable as Preston.
Defiance	1890	1892	Late.
Democrat Spring	1892	1892	Poor milling quality; late.
Dion's	1894	1902	Weak straw; medium yield.
Downy Riga	1905	1905	
Dufferin	1896	1902	Not as valuable as Preston.
Early Red Fife	1909 1921	1911 1922	Very subject to rust.
Early Riga or Riga	1899	1910	Weak straw; rust; low yield.
Early Triumph	1922	....	
Ebert	1899	1902	Not as valuable as Preston.
Emporium	1892	1899	Identical with Red Fern.
Essex	1901	1903	Rust.

VARIETY TESTS OF SPRING WHEAT, 1889–1923—*Continued*

Variety	Date first tested	Date dropped from tes	Why dropped from test
Eureka	1889	1891	Identical with Red Fern.
Fraser	1899	1904	Low yield; not as valuable as Preston.
French Imperial	1890	1892	Soft.
Garnet (Ottawa 652)	1918	....	
Garton's No. 46	1912	1913	Not equal to Marquis in yield or milling quality.
Gehun	1891	1896	Rusts badly; low yield; a mixture.
Golden Drop	1889	1899	Soft; yield medium.
Goose	1892 1895	1893 1907	A macaroni wheat; not desirable for bread making.
Great Western	1892	1893	Low yield.
Greek Summer	1890	1890	Low yield.
Green Mountain	1890	1890	
Hard Red Calcutta	1889	1893	Low yield.
Harold	1898	1902	Low yield; subject to rust.
Hastings	1901	1904	Rust.
Herrison Bearded	1893	1907	Makes bread of unattractive colour.
Herrison's Beardless	1890	1890	Low yield.
Hueston's	1890 1893	1890 1893	Late.
Hungarian	1895	1904	
Hungarian Mountain	1890	1895	Identical with Red Fife.
Hungarian White	1907	1909	Low yield.
Huron	1894	1911	Displaced by Marquis which is of better milling quality and more productive.
Indian Karachi	1890	1892	Low yield.
Japanese	1900	1903	Low yield.
Johnston's	1892	1892	Late.
Judket	1889	1891	Late.
Kent	1891	1892	Rusts badly.
Kitchener	1916	....	
Kota	1921	....	
Kubanka	1920	....	
Ladoga	1889	1902	Low yield; replaced by Preston and other early cross-breds.
Lahone	1890	1890	Poor quality.
Laurel	1899	1906	Inferior milling quality.
M.A.C. No. 10	1922	1922	
Magyar	1890	1890	Low yield; very late.
Mahmoudi	1904	1907	A macaroni wheat; not desirable for bread making.
Major	1894	1895	Not as valuable as Preston.
Major (Ottawa 522)	1920	....	
Manifold	1893	1893	Low yield.
Marquis	1908	....	
Mason	1898	1902	Low yield.
Master (Ottawa 520)	1922	....	
Minnesota No. 149 or Power's Fife	1901	1905	Identical with Red Fife.
Minnesota No. 163	1901	1905	Rusts badly.
Minnesota No. 169, or Hayne's Blue-stem	1901	1906	Late; milling quality below Fife.
Minnesota No. 181, or McKendry's Fife	1901	1905	Not equal to Red Fife in milling quality.
Minnesota No. 188	1908	1909	
Mishriki	1903	1903	Rusts; low yield.
Monarch	1894	1905	Identical with White Russian.
Nameless	1892	1892	
Newton Club	1890	1890	Low yield.
No. 1701	1890	1890	Late.
Norval	1899	1903	Low yield; not as valuable as Preston.
Old Red River	1889	1898	Rust; poor quality.
Onega	1890	1890	Low yield.
Oregon Club	1903	1903	Rust; low yield.
Ottawa	1892	1894	Low yield.
Pelissier	1920	1921	Not equal to Kubanka as a macaroni wheat.
Percy	1894	1909	Not as valuable as Preston.
Pioneer	1911	1914	Not as valuable as Marquis.
Plumper	1898	1904	Low yield; type not fixed.
Polonian	1899	1900	Not a milling wheat.
Prelude	1911	1915	Low yield; weak straw.
Preston	1893	1911	Displaced by Marquis which is of better milling quality.

VARIETY TESTS OF SPRING WHEAT, 1889–1923—*Concluded*

Variety	Date first tested	Date dropped from test	Why dropped from test
Prince	1892	1893	Low yield.
Pringle's Champlain	1890	1910	Not as valuable as Red Fife.
Progress	1896	1903	Not as valuable as Preston.
Red Bobs	1918	....	
Red Connell	1889	1890	Less productive than Red Fife.
Red Fern	1889	1908	Lower yield than Red Fife.
Red Fife	1889	....	
Rio Grande	1889	1904	Not equal to Fife in milling quality.
Red Swedish	1899	1903	Rust.
Reward (Ottawa 928)	1922	....	
Rideau	1895	1902	Not as valuable as Preston.
Robin's Rust Proof	1901	1903	Rust.
Roumanian	1899	1907	A macaroni wheat, not desirable for bread making.
Ruby	1918	....	
Russian Ghirka	1890	1890	Low yield.
Russian Hard Tag	1889	1892	Low yield; inferior quality.
Saxonka	1889	1891	Rusts badly; inferior milling quality.
Sejar	1903	1903	Low yield.
Simla	1890	1890	Low yield.
Soft Red Calcutta	1890	1890	Low yield, soft.
Spiti Valley	1890	1890	Very low yield.
Stanley	1894	1911	Displaced by Marquis which is better milling quality and more productive.
Stonewall	1893	1893	Low yield.
Supreme	1922	....	
Talavera	1890	1890	Low yield, very late.
Trial	1893	1893	Low yield.
Velvet Chaff or Blue Stem	1896	1902	Late, milling quality not equal to Red Fife; rust.
Velvet Don	1903	1903	A macaroni wheat, not suitable for milling.
Vernon	1896	1903	Not as valuable as Preston.
Waugh's Delhi	1891	1892	
Weldon	1899	1905	Not as valuable as Preston.
Wellman's Fife	1890	1905	Identical with White Russian.
White Connell	1889	1903	An impure strain of White Fife.
White Delhi	1889	1893	Low yield; mixed sort.
White Fife	1889	1911	Unpopular colour; no better than Red Fife.
White Russian	1892	1908	Late; not equal to Red Fife in milling quality.
Wright's Favorite	1894	1895	Low yield.
Yellow Gharnovka	1904	1907	A macaroni wheat not desirable for bread making.
Yeoman's Defiance	1894	1895	Late.

VARIETIES OF SPRING WHEAT NOW UNDER TEST

The 1923 test of varieties included fifteen varieties of hard red spring wheat (as well as varieties of durum wheat and of winter wheat). The following table shows the yields per acre of these varieties for the six years 1918-1923 or for such of these years as they have been grown:—

YIELDS OF WHEAT VARIETIES 1918–1923

Variety	Yield per acre, 1918	Yield per acre, 1919	Yield per acre, 1920	Yield per acre, 1921	Yield per acre, 1922	Yield per acre, 1923	Average yield per acre for six years
	bush. lbs.	bush. lbs.	bush. lbs.	bush. lbs.	bush. lbs.	bush. lbs.	bush. lbs.
Marquis, Ottawa 15	26 30	30 ..	32 30	30 20	49 30	28 5	32 49
Garnet, Ottawa 652	24 25	22 20	30 10	35 ..	47 30	28 30	31 19
Red Bobs	23 20	23 ..	31 10	24 40	52 20	25 ..	29 55
Major, Ottawa 522	29 30	24 20	35 ..	29 40	35 40	22 20	29 25
Kitchener	30 40	22 ..	29 20	24 ..	51 50	16 10	29 3
Crown, Ottawa 253	21 20	23 20	29 20	28 20	44 10	25 50	28 43
Ruby, Ottawa 623	25 12	25 ..	29 10	26 ..	33 50	26 50	27 40
Red Fife	27 50	20 20	26 40	20 ..	46 40	10 5	25 6
Criddle's Marquis	.. ..	.. ..	.. ..	24 40	58 40	13 30	.. ..
Kota	.. ..	.. ..	.. ..	20 20	47 ..	31 20	.. ..
Supreme	.. ..	.. ..	.. ..	.. ..	54 ..	17 20	.. ..
Early Triumph	.. ..	.. ..	.. ..	.. ..	53 ..	17 20	.. ..
Reward, Ottawa 928	.. ..	.. ..	.. ..	.. ..	35 40	31 20	.. ..
Master, Ottawa 520	.. ..	.. ..	.. ..	.. ..	28 ..	22 20	.. ..
Marquis 10 B	.. ..	.. ..	.. ..	.. ..	.. ..	23 ..	.. ..

WHEAT VARIETIES—EARLINESS AND WEIGHT PER BUSHEL

Variety	Average number of days maturing, 1918–23	Average weight per bushel, 1918–23
		lbs.
Marquis	102·0	60·3
Garnet, Ottawa 652	94·8	61·4
Red Bobs	100·3	58·6
Kitchener	103·5	56·5
Major, Ottawa 522	98·0	58·1
Crown, Ottawa 353	95·5	60·2
Ruby, Ottawa 623	96·3	61·5
Red Fife	105·7	56·0

Marquis is now grown very much more extensively than any other variety of wheat in Manitoba, probably over seventy-five per cent of the crop being of this variety. The above tables show that the results obtained at Brandon justify this. In the average of the past six years it has outyielded all other varieties. At the same time its susceptibility to rust has brought about general dissatisfaction with this variety. There is a general search for something to take its place, and if a satisfactory substitute could be found it would rapidly be adopted. In years when rust is not a factor, Marquis has all the characteristics desired in a variety for Manitoba. It is high yielding, of excellent milling quality and attractive appearance, strong in the straw, not given to excessive growth of straw, not easily shattered and sufficiently early for practically all parts of this province. But it is not any more resistant to black stem rust than other varieties of the same type and degree of earliness and consequently has lost favour in recent years and especially in 1923.

Red Bobs is a variety of similar general type to Marquis. It was selected by Seager Wheeler, of Rosthern, out of the old white variety "Bobs." Red Bobs, had it come on the scene before Marquis would have been a great wheat, but coming on after Marquis it was not quite good enough to make a place for itself. It has averaged 1·7 days earlier than Marquis during the past six years at Brandon. The amount of infection of rust has been about the same but the injury seems to have been greater as the weight per bushel has been 1·7 pounds less. It has yielded on the average just under 3 bushels less per acre than Marquis. There is less grown in Manitoba than when first introduced and it seems likely to disappear so far as this province is concerned.

Kitchener is another introduction of Seager Wheeler's. It has less merit than Red Bobs, as it is later, much more subject to rust and produces a less attractive sample of wheat. It outyielded Marquis in 1918 and 1922, but was below in the other four of the last six years and is over 3 bushels down on the average.

Red Fife is continued in the test, not because of any value under present conditions, but largely as a standard of comparison, and because some people remembering its former success and not having seen it for many years wonder how it would do now. That question is effectively answered by the figures in these tables.

Ruby, Ottawa 623 is a comparatively new variety, originated by the former Dominion Cerealist, Dr. C. E. Saunders, and has proven of some value in northern Manitoba. It is not as productive as Marquis under favourable conditions, and has averaged 5 bushels less per acre. However, it is five or six days earlier and hence escapes frost and rust much better. In 1923 it weighed 60 pounds per bushel where Marquis weighed only 51·5 pounds, due to the difference in rust damage. It is of first class milling quality and is otherwise of desirable type.

Garnet, Ottawa 652, is another new variety of Dr. Saunders' introduction that promises to be of some value. It is earlier still than Ruby averaging seven days earlier than Marquis in recent years. It has come within $1\frac{1}{2}$ bushels of equalling Marquis in yield in the average of the past six years. It has escaped the full effect of the rust attacks by its earliness. It produces wheat of first class quality. The straw is strong and the plant free from undesirable characteristics.

Reward, Ottawa 928, has been grown at Brandon only two seasons, and consequently it is too soon to form definite opinions. It has, however, aroused some hopes from the fact that in 1923 it tied for the highest yield in the test and produced grain weighing 62.5 pounds to the bushel despite the rust attack. In 1922 it weighed $64\frac{3}{4}$ pounds per bushel, in both seasons it was the heaviest sample from the test plots. In earliness it is about the same as Ruby.

None of these new varieties of Dr. Saunders are rust resistant. Any immunity they may appear to have is due to their escape by their earliness.

Kota is the only hard red spring wheat in the test which shows resistance to black stem rust. This variety comes from the North Dakota Agricultural College. It appears to have very considerable value, at least temporarily, in meeting the present situation in regard to rust. It has been included in these tests only three years. In the two seasons when rust was not the limiting factor it has not yielded as well as Marquis, but in 1923 it tied with Reward for first place. It has also produced plump wheat in 1923 weighing 61 pounds per bushel as compared with Marquis, 51.5 pounds. While it is resistant to black stem rust, it is quite susceptible to the orange leaf rust and the crop looks as rusty as any other variety. However, this variety of rust does not do much damage to the grain as it does not puncture the stems. Kota has, however, some serious faults, one especially that limits its usefulness; it has weak straw

and lodges easily when moisture is plentiful. The heads are also easily shattered. The fact that it is bearded is not in its favour though it can hardly be counted as a real fault.

The other varieties included in recent tests have been under observation for too short a period to satisfactorily appraise their value.

DURUM WHEAT VARIETY TESTS

A few varieties of durum or macaroni wheat were included in the test from 1899 up to 1907. At that time these varieties were dropped as they were not considered suitable for breadmaking.

In recent years there has been an increased interest in durum wheats, particularly since rust and drought have made the growing of the common varieties hazardous. The area devoted to durum wheat growing is increasing in Manitoba. In order to have some up-to-date data on this type of wheat, two strains of Kubanka, which is generally supposed to be the best durum, were included in the 1920 test. Since then others have been added and in 1923 six durum varieties were included in the test. The 1923 test of these varieties gave the following results:—

VARIETIES OF DURUM WHEAT 1923 TEST

Variety	Number of days maturing	Strength of straw on scale of ten points	Yield per acre		Weight per bushel	Percentage of stem rust
			bush.	lbs.	lbs.	
Monad	104	4	41	20	60·0	Trace
Acme	106	5	38	40	62·0	Trace
Arnautka	103	4	27	50	53·0	60
Mindum	104	6	25	40	59·0	75
Kubanka	99	7	19	20	53·5	60
Kahla	98	6	13	..	53·0	80
(For comparison)						
Marquis	98	10	28	5	51·5	90
Kota	97	4	31	20	61·0	Trace

Kubanka and Marquis have been grown in comparison with each other for four years with the following results:—

	Average number of days maturing	Average yield per acre 4 years	
		bush.	lbs.
Marquis	97·5	35	6
Kubanka	100·1	33	19

These tests show the supposed ability of Kubanka to resist rust and outyield Marquis to have been much overestimated by those who look to it as a means of escape from present difficulties. In 1923 it rusted quite badly, was reduced in weight per bushel nearly as much as Marquis and yielded much less. It has also the faults of being later and weaker strawed.

Monad and Acme were the only durum varieties in this test that outyielded the best hard red varieties. These two were practically completely free from rust. However, they have the disadvantages of being still later and weaker in the straw than Kubanka and being less valuable for macaroni than that variety.

While the use of durum varieties may appear to be necessary to some farmers, particularly in the southwestern portion of the province, these results do not indicate that this is to be the permanent solution of the problem of a satisfactory variety of wheat. The place of Canada's wheat in the markets of the world is due to its value for making bread of the best quality and finest colour. While a limited amount of macaroni wheat may be marketed satisfactorily there can hardly be the outlet for the volume that would be produced if a general change were made. The advantages from growing it so far as yield are concerned are hardly sufficient to justify the lessened intrinsic worth of the product.

Western Canada needs a rust-resistant wheat with the qualities of Marquis. Our plant breeders are striving earnestly to meet that need, and it is to be hoped that success will soon crown their efforts.

WINTER WHEAT

Tests of varieties of winter wheat have been made from time to time at Brandon. The result has nearly always been unsatisfactory. Either the wheat has been entirely winter-killed, or so thinned out as to be a light yield. In 1909-10 a successful wintering of winter wheat was made. In 1922-23, it wintered successfully again and excellent results were obtained, yields, of over 50 bushels per acre being obtained in 1923 when spring wheat was badly damaged by rust. The best results in 1923 were obtained from the Kanred variety. However, conditions in the winter of 1922-23 were unusually favourable, snow coming early in the fall and remaining late in the spring, so that this success must be discounted. Unless similar results can be obtained under less favourable conditions, winter wheat growing must continue to be considered as a very hazardous undertaking.

SEED

FROZEN vs. UNFROZEN SEED

In the early days in Manitoba the factor of frost entered very largely into wheat growing calculations. Consequently the use of frozen grain for seed became a subject of dispute. It was apparent that the vitality of frozen wheat was not entirely destroyed, for it was common experience that frozen wheat would grow. From this experience came the opinion held by some that frozen wheat was equal to unfrozen, and being much less profitable to sell, it was sometimes kept for seed and the best grades sold for milling. In 1889 and 1890 tests were made to compare good sound seed with that which had been damaged by frost. Several grades were used; it will serve our purpose in reviewing the experiment at this date to summarize the results on three grades. The yields reported herewith are the average of three tests.

Frozen vs. Unfrozen Seed

Seed used	Yield per acre	
	bush.	lbs.
No. 1 hard	16	29
No. 1 frosted	15	43
No. 4 frosted	13	32

The deduction made from these tests was that slight freezing had very little effect on the value of seed wheat but that when the seed was badly frozen its yielding power was materially reduced.

THE VALUE FOR SEED OF THE COMMERCIAL GRADES OF WHEAT

In the years 1909-11, experiments were conducted to determine the value for seed of the various standard and commercial grades of wheat. Samples were obtained each year from the Chief Grain Inspector at Winnipeg. They were sown on uniformly prepared land, summer-fallow in each case. The average results obtained for the three years were as follows:—

GRADES OF WHEAT FOR SEED

Grade	Average yield per acre		Average weight per bushel
	bush.	lbs.	lbs.
No. 1 Hard	40	7	61
No. 1 Northern	40	..	61
No. 2 Northern	40	7	60¾
No. 3 Northern	38	40	60½
No. 4	38	17	60½
No. 5	37	31	60½
No. 6	33	54	60
Feed	30	21	60

The three highest grades gave equal results which might perhaps be expected as No. 2 Northern wheat is really very good, being sound and reasonably plump, usually falling below No. 1 on account of being off colour or for other minor defects. From No. 2 to No. 5 the decrease is hardly as great as would be expected, and in explanation of this it is suggested in the comment on the experiment that the ideal conditions which were provided in the soil used, gave these poorer grades a better chance than they would get under average farm conditions.

The difference of almost 10 bushels between Feed wheat and No. 2, and of over 6 bushels between No. 6 and No. 2 shows the distinct inferiority of these low grades for seed purposes.

HAND SELECTION OF HEADS FOR SEED

From 1900 to 1905, inclusive, an experiment was conducted to determine whether or not the yield of wheat could be increased by selecting, by hand, the largest heads of grain out of the crop, and using these for seed. For five years these tests were conducted with negative results. In 1900, five varieties were used, and the unselected produced 50 pounds per acre more than the selected; in 1901, thirty-four varieties averaged 9 pounds per acre higher for unselected. In 1902-03 and '04, the selected lots outyielded the unselected by 15 pounds, 11 pounds and 54 pounds on the average. In other words the average difference between selected and unselected was less than a bushel per acre in each of these five years. There is no particular explanation for these results to be found in the description of the experiment or in the comments thereon, and the deduction that hand selection was valueless would seem to be inevitable were it not for the results in the sixth year of the experiment. In this year the selections were made by Dr. C. E. Saunders, Dominion Cerealist, and it is remarked that he made them carefully. Whatever the reason, the results are very different. Everyone of the six varieties used shows a marked increase from hand selection and the average increase for the six is 5 bushels, 7 pounds per acre.

One is tempted to suspect that in the first five years the selection was a more or less superficial picking of big heads without any careful study of the productiveness of the plants that bore them, or of the type of the heads

picked. The results obtained from such selections are likely to be disappointing. But where an intelligent study of all the characteristics indicating productivity is made, as was the case in the selection made by Dr. Saunders, results may be obtained.

HOME-GROWN vs. CHANGED SEED

A test was made in 1893 comparing home-grown Red Fife seed wheat with seed brought from the Northwest Territories (now Saskatchewan). The home-grown seed outyielded the changed seed by 2 bushels per acre, and was its equal in earliness and height. One test does not prove anything, but so far as it goes it is evidence in support of the opinion that a change in itself is of no advantage, and that a change should be made only when by doing so a variety or strain known to be better than that in use can be obtained.

PREVENTION OF SMUT

One of the first difficulties to confront the early wheat grower was the disease of smut in his wheat. One of the first lines of experiment undertaken at the Farm was the testing of methods of controlling smut. From the inauguration of the Farm up till 1911 experiments of this kind were tried almost every year. At first bluestone (copper sulphate) was the most successful treatment, and by 1893 it is reported that it had come into general use. In 1900 formalin was included in the test for the first time.

In the report for the crop season of 1910, the results of the experiments conducted up to that date are summarized by Mr. Murray as follows:—

"During the past twenty years various chemicals have been tested to secure one for the prevention of smut in grain crops. Little difficulty has been experienced in controlling this disease in wheat or in oats, but no practical method has yet been introduced that will entirely prevent it in barley. The formalin treatment has been found, after numerous trials, to be highly satisfactory. Formalin can now be secured almost anywhere; it is inexpensive, the solution is easily prepared, and its efficiency when properly applied is beyond doubt. One pound of formalin is sufficient to make 32 gallons of solution, and this quantity will easily cover 40 bushels of wheat, or about 28 of oats. Dipping and sprinkling have given equally good results, but carelessness in either method of treatment is sure to bring disappointment.

"Bluestone has been found effective as a reagent for destroying smut, but its use has not been attended with quite as satisfactory results as formalin. A bluestone solution of the proper strength is prepared by dissolving 1 pound of bluestone in 6 gallons of soft water. As with the formalin solution, it makes no difference how this solution is applied so long as every kernel of grain is thoroughly moistened.

"Other treatments that have been on trial, as preventatives of smut, include those with sulphide of potassium, sulphate of iron, agricultural bluestone, massel powder, anti-fungi, salt, and hot water. None of these has proven to be nearly as effectual as either formalin or bluestone. The hot water treatment and the sulphide of potassium both effectively prevented the disease, but the methods of application are too tedious to permit of either treatment coming into general use. Agricultural bluestone and anti-fungi are both mixtures of copper sulphate and iron sulphate, and their effectiveness is dependent upon the proportion of suphate of copper that they contain, sulphate of iron being of little value as a fungicide.

" The loose smut of wheat is a distinct disease from the stinking smut and cannot be controlled by formalin or bluestone. The only sure method for it yet discovered is what is known as the ' hot water treatment.' For this treatment the grain is placed in a bag and immersed in water at about 115° F. After it is well warmed through it is placed in water which is kept at a temperature between 130° and 135° F. The grain should be stirred occasionally and allowed to remain in the water for fifteen minutes. Afterwards it should be spread on a clean floor to dry.

" While this treatment is effective in killing the smut spores it is not adapted to being used in general farm practice as it is very slow and requires to be carefully performed."

In 1911 the scope of the experiment was widened to cover more varying strengths of treatment both with bluestone and formalin. The results obtained are as follows:—

Treatment for Smut

Treatment	Number of smutty heads per thousand	Yield per acre	
		bush.	lbs.
Untreated	161	44	40
Immersed in bluestone 1 lb. to 4 gals. water		38	40
Immersed in bluestone 1 lb. to 6 gals. water		40	40
Sprinkled with bluestone 1 lb. to 6 gals. water	3	40	..
Immersed in bluestone 1 lb. to 8 gals. water	4	44	..
Immersed in bluestone 1 lb. to 10 gals. water	5	44	40
Immersed in formalin 1 lb. to 25 gals. water		38	40
Immersed in formalin 1 lb. to 30 gals. water		46	20
Immersed in formalin 1 lb. to 35 gals. water		47	40
Sprinkled with formalin 1 lb. to 35 gals. water		45	20
Immersed in formalin 1 lb. to 40 gals. water		48	40

In this test the formalin gave the best results. Not only has it been more completely effective in killing the smut but it has had no influence in depressing the wheat yields (except in the case of the strongest solution) while the bluestone has depressed the wheat yields throughout. The strongest solution of formalin, 1 pound to 25 gallons, has apparently been injurious to the wheat.

Sprinkling when done thoroughly has given as good results as immersion and is more easily applied.

The use of 1 pound of formalin to 35 or 40 gallons of water is now in general practice throughout the province and has given satisfactory results.

SEEDING

DATES OF SEEDING

An experiment in regard to dates of sowing wheat was carried on from 1893 to 1899, inclusive. Each year a plot of wheat was sown at the earliest possible date that the land was fit for work. Successive sowings were made at one, two, three, four, and five weeks later. The Red Fife variety of wheat, the standard at that time, was used. The date of first seeding varied very materially with the season. The results obtained from this test are as follows:—

DATES OF SEEDING

Year	Date of first sowing	Yield per acre from first sowing		Yield per acre from sowing one week after first		Yield per acre from sowing two weeks after first		Yield per acre from sowing three weeks after first		Yield per acre from sowing four weeks after first		Yield per acre from sowing five weeks after first	
		bush.	lbs.	bush.	lbs.	bush.	lbs.	bush.	lbs.	bush.	lbs.	bush.	lbs.
1893	May 2	28	10	33	20	28	30	26	40	22	10	..	..
1894	May 1	33	40	31	10	33	00	32	10	29	20	22	40
1895	April 6	43	50	43	..	44	30	46	50	25	50	25	30
1896	May 8	27	40	28	20	28	50	21	..	..	..	..	..
1897	April 28	32	50	33	00	31	00	30	50	26	00	21	20
1898	April 23	45	20	34	20	30	40	31	..	29	..	16	40
1899	May 1	38	20	34	40	32	..	29	20	25	20	..	..
Average		35	41	33	50	32	41	31	7	26	17	21	32

It will be noted that the average yield gradually lowers for the first four weeks and then slumps off badly for the last two. Picking out the dates where the best yields are found, one finds that the last two weeks of April and the first week of May have most of the good ones. The general conclusion would appear to be justified that except in abnormally early seasons the first date possible for seeding wheat is the best, and that after about May 10 or May 12 the prospects of a good yield are materially lessened.

RATES OF SEEDING

In 1898, 1901, 1911, and 1912 tests were made in which different quantities of seed were compared. In 1898 and 1901 Red Fife wheat was used for the test and the quantities tried were 4 pecks, 5 pecks, and 6 pecks per acre. The land used had been summer-fallowed the year before in each case. The average results obtained for these years are as follows:—

RATES OF SEEDING WHEAT ON SUMMER-FALLOW, 1898 AND 1901

Rate of Seeding	Average number of days maturing	Average yield per acre	
		bush.	lbs.
4 pecks per acre	115	24	30
5 pecks per acre	115	29	..
6 pecks per acre	115	29	50

In 1911 and 1912 a wider range of rates was covered in the test and in 1912 a test on fall-ploughed stubble land was added to the test on fallow. Marquis wheat was used for the test in these seasons. The average results for the two years of the test on summer-fallow were as follows:—

RATES OF SEEDING WHEAT ON SUMMER-FALLOW, 1911–12

Rate of Seeding	Average number of days maturing	Average yield per acre	
		bush.	lbs.
2 bushels per acre	108·5	41	50
1¾ " "	108·5	41	..
1½ " "	110·0	37	50
1¼ " "	110·0	37	20
1 " "	110·5	34	..
¾ " "	111·0	35	40

Rates of Seeding Wheat on Stubble Land, 1912

Rate of Seeding	Number of days maturing	Yield per acre
		bush. lbs.
2 bushels per acre	102	25 20
1¾ " "	104	24 ..
1½ " "	104	28 40
1¼ " "	105	27 20
1 " "	106	31 20
¾ " "	108	32 ..

It will be noted that on summer-fallow land the tendency has been for the yield of wheat to increase as the quantity of seed has increased. The increase from two bushels as compared with one and three-quarters is too small to mean much, but up to one and three-quarters the increases are material. It may be noted that the land used is heavy rich land.

On the stubble land, while there is some inconsistency in the results, the general tendency is to a better yield from light seeding.

In regard to the time of maturity no difference due to quantity of seed was observed in the earlier tests, but in the 1911-12 tests quite material hastening of maturity was observed as the result of thick seeding.

DEPTH OF SEEDING

From 1912 to 1923 an experiment has been conducted testing the effect of sowing wheat at 1, 2, 3, and 4 inches deep. The soil used is heavy clay loam and the test has been conducted each year on summer-fallow. The average results for ten years up to and including 1923 are as follows:—

Depth of Seeding

Depth of Seeding	Average yield per acre for ten years
	bush. lbs.
1 inch	35 48
2 inches	38 36
3 inches	39 ..
4 inches	35 15

It will be noticed that the intermediate depths have given the best results. Similar results were obtained with oats on fall-ploughed land.

The proper depth at which to sow grain will depend on the kind and condition of the soil. The seed should be placed in firm moist soil. If too near the surface it is in danger of surface drying, if too deep it has too far to grow to reach the open air and is weakened by the effort. Heavy, finely worked or moist soil is consequently more suitable for shallow seeding than light, lumpy or dry soil. Under most conditions, seeding to a depth of from two to three inches will be found to give satisfactory results.

THE SUMMER-FALLOW AND SUBSTITUTES

The practice of summer-fallowing has been the corner-stone of the development of wheat raising in Manitoba up to the present time. The early settlers soon found out that a year's moisture was not sufficient for a year's crop when grain crops were grown year after year and that weeds multiplied badly under such a system. So the method of leaving the land fallow about every fourth year was hit upon, and this was further developed into cultivating it thoroughly during that year so as to eradicate the weeds if possible and to store moisture more efficiently.

SUMMER-FALLOW VS. SPRING AND FALL PLOUGHING

One of the first experiments undertaken when the Farm was new, was a comparison of summer-fallowing against spring or fall ploughing of stubble land. In 1892 and from 1895 to 1899 inclusive this experiment was tried. The average yields obtained from these methods for these six years are as follows:—

SUMMER-FALLOW VS. SPRING PLOUGHING VS. FALL PLOUGHING

Time of Ploughing	Average yield per acre	
	bush.	lbs.
Summer-fallowing	38	16
Spring ploughing	29	13
Fall ploughing	24	41

While on the surface this test is a comparison of times of ploughing, the real difference between the first method and the latter two is that in the one case there has been a season of idleness for the land, while in the other, one crop follows another. The increase in yield obtained by summer-fallow may fairly be attributed to the fact of it being a fallow and not to the date of ploughing.

General experience on this topic is even more conclusive than this experiment and so long as cereal crops form the whole produce of the farm the need of the regularly recurring fallow is a matter of common knowledge.

SUMMER-FALLOW CULTURE TESTS

ONE VS. TWO PLOUGHINGS FOR SUMMER-FALLOW

A test of one vs. two ploughings of summer-fallow was first made in 1891. This resulted in a yield of 30 bushels 41 pounds from land ploughed on June 26, as against 27 bushels 57 pounds from land ploughed on the same date and again on August 1.

From 1912 to 1921, inclusive, an experiment on summer-fallow treatment included a comparison of one and two ploughings. This was compared at 4-, 6-, and 8-inch depths. The following average yields were obtained for nine years, omitting 1916, in which year the crop was destroyed by rust.

PLOUGHING ONCE VERSUS TWICE

Plot No.	Treatment given	Yield of wheat on summer-fallow, nine-year average	
		bush.	lbs.
1	Plough 4 inches June, pack if necessary and practicable, cultivate as necessary	34	36
2	Plough 6 inches June, pack if necessary and practicable, cultivate as necessary	34	21
3	Plough 8 inches June, pack if necessary and practicable, cultivate as necessary	35	30
4	Plough 4 inches June, cultivate, plough 4 inches September, harrow	34	4
5	Plough 6 inches June, cultivate, plough 6 inches September, harrow	33	41
6	Plough 8 inches June, cultivate, plough 8 inches September, harrow	33	5
7	Plough 6 inches June, cultivate, plough 4 inches September, harrow	34	54
8	Plough 4 inches June, cultivate, plough 6 inches September, harrow	33	39
9	Plough 4 inches June, early as possible, cultivate, plough 6 inches September, leave untouched	32	22
	Average of 3 plots, ploughed once	34	49
	Average of 6 plots, ploughed twice	33	37

In 1922 only the six-inch depth of this test was continued, with the result that one ploughing gave a yield of 41 bushels 20 pounds and two ploughings gave a yield of 37 bushels 20 pounds.

The land used for this experiment had the ordinary annual weeds in it but was free from grasses, thistles or other perennials. Also it should be noted that the single ploughing was always followed by thorough cultivation throughout the season. Under these circumstances the conclusion would appear to be justified that the second ploughing of summer-fallow land is waste effort. The returns have never been materially increased by the second ploughing, and on the average they are lower.

However, in this connection, it should be said that where the principal object of summer-fallow is the eradication of couch grass, it has been found that ploughing twice is the best method. And often in combatting Canada thistles or sow thistles if cultivation is interrupted by wet weather or other work a second ploughing is advantageous.

DEPTH OF PLOUGHING FOR SUMMER-FALLOW

The experiment described above under once-vs. twice-ploughed includes a comparison of three depths of ploughing. These brought out in direct comparison show the following results:—

DEPTH OF PLOUGHING SUMMER-FALLOW

Depth of Ploughing	Average yield per acre for nine years					
	One ploughing		Two ploughings		Average of two methods	
	bush.	lbs.	bush.	lbs.	bush.	lbs.
4 inches	34	36	34	4	34	20
6 inches	34	21	33	41	34	1
8 inches	35	30	33	5	34	17·5

During the same ten years 1912-1922 (omitting 1916), another experiment has been conducted in which depth of ploughing was the sole point under test and in which a much wider range of depths was covered. Ordinary ploughing from 3 to 8 inches in depth, and subsoiling 4 inches below 5-, 6-, 7,- and 8-inch ploughing, thus making the total depth of cultivation 9, 10, 11 and 12 inches, was tried. The average results obtained during the ten years are as follows:—

DEPTH OF PLOUGHING SUMMER-FALLOW

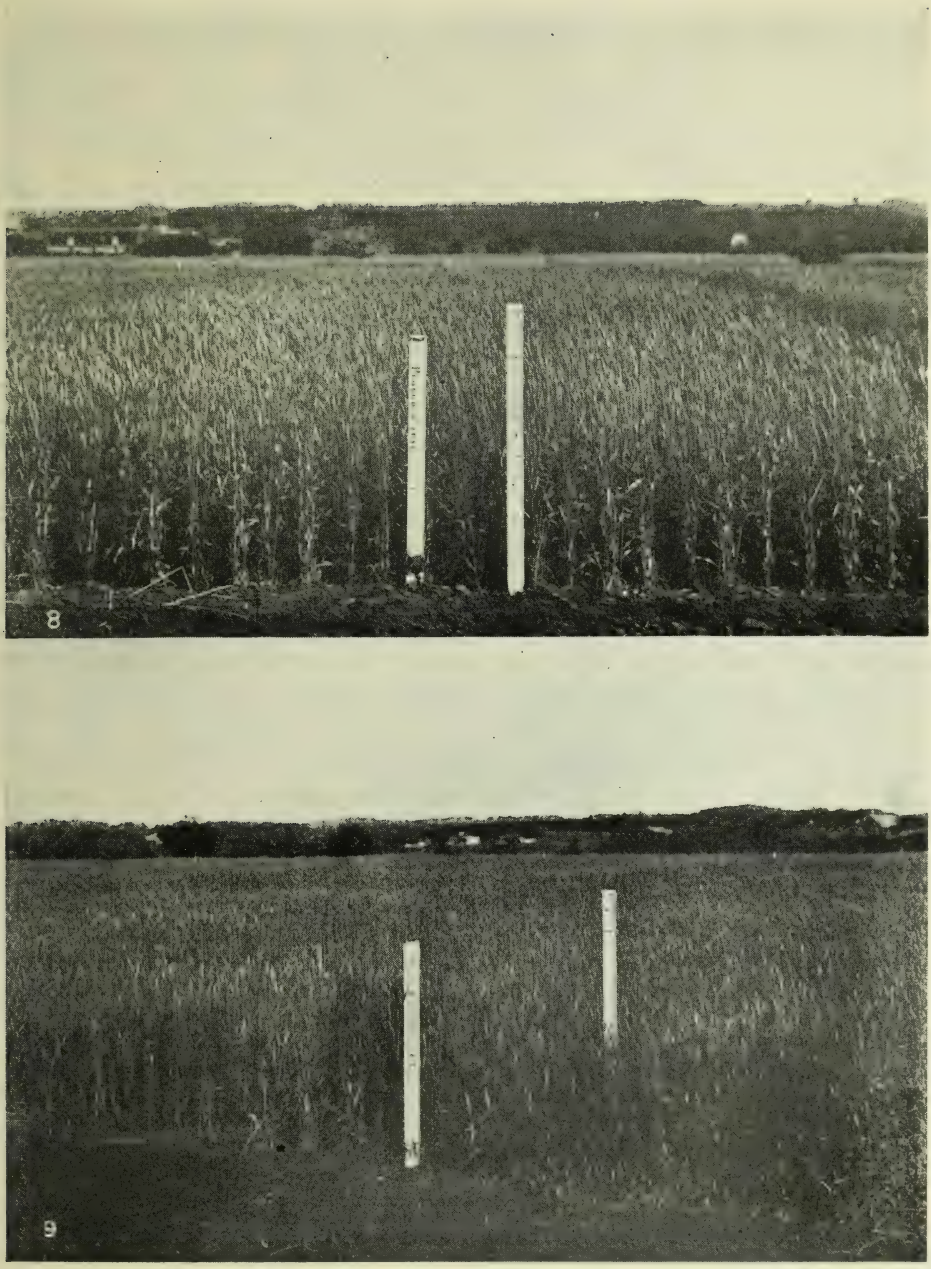
Depth of Ploughing	Average yield per acre for ten years	
	bush.	lbs.
3 inches	40	43
4 inches	41	29
5 inches	41	56
6 inches	41	8
7 inches	40	5
8 inches	41	55
5 inches ploughing and 4 inches subsoiling	39	48
6 inches ploughing and 4 inches subsoiling	40	7
7 inches ploughing and 4 inches subsoiling	40	32
8 inches ploughing and 4 inches subsoiling	38	37

It will be seen from these figures that the generally accepted belief among our best farmers and agricultural authorities that deep ploughing is good farm practice has not been borne out by experimental results. Ploughing 8 inches deep has given the same results as 5 inches for ten years and the advantage of 5-inch ploughing over 3 inches is not large enough to be above suspicion as mere experimental error. The subsoiled plots have been adversely, if at all, affected. Since deep ploughing is more costly than shallow, then in so far as these results can be applied, it is a waste to plough deep. The writer has been convinced by these figures that the importance of deep ploughing has been over-estimated by himself as well as others. When a plot that has been ploughed three inches deep for eleven years, and never deeper, gives an average yield for the summer-fallow crops of over 40 bushels of wheat (incidentally the average crop of oats in the succeeding year has been 70 bushels) the need for deep ploughing for that particular soil is obviously not very great. The two experiments are corroborative of each other. One is on a ridge of lighter soil running across the experimental field and the other on lower, heavier soil, yet neither has shown any material advantage for the deep ploughing.

The writer is not prepared to say that deep ploughing is never advantageous. In fact he still thinks that under certain circumstances it is called for; that, however, is a mere opinion, and not supported by experimental evidence.

DATE OF PLOUGHING SUMMER-FALLOW

One feature of the summer-fallowing experiment which has run from 1912 to 1922, inclusive, is a comparison of May 15, June 15, and July 15 as dates for ploughing summer-fallow. No cultivation is given the land previous to the ploughing. In each case the ploughing is 6 inches. Thorough cultivation is given throughout the remainder of the season. The average results for ten years (1916 omitted) are as follows:—



DATE OF PLOUGHING SUMMER-FALLOW

(Upper) Wheat on June 15 ploughing, uniform and clean with average yield for 10 years of 35 bus. 33 lb.
(Lower) Wheat on July 15 ploughing, uneven and weedy with an average yield for 10 years of 20 bus. 48 lb..

DATE OF PLOUGHING SUMMER-FALLOW

Date of Ploughing	Average yield per acre for ten years
	bush. lbs.
May 15	37 41
June 15	35 33
July 15	29 48

The crop on July ploughing has always been below that on the earlier ploughing. This is doubtless largely due to the waste of moisture brought about by the growth of weeds and volunteer grain on the late-ploughed plot. There is the further disadvantage that ripe seeds develop which are ploughed in and in that way store up trouble for the future.

The May ploughing has produced about 2 bushels per acre more than the June ploughing. This is not enough advantage to justify allowing fallow ploughing to interfere with necessary spring work but it does indicate that it is worth while to get at summer-fallow ploughing just as soon as it is practical to do so.

FALL CULTIVATION BEFORE SUMMER-FALLOWING

Another feature of the summer-fallowing experiment, run from 1912 to 1922, inclusive, is a test of the value of fall cultivation before the summer-fallow season. Three plots were used, one of them was skim-ploughed in the fall, the next was well disked and the third received no fall cultivation. All three were ploughed 6 inches deep the next June and cultivated alike from then on. The average results obtained for ten years (1916 omitted) are as follows:—

FALL CULTIVATION BEFORE SUMMER-FALLOWING

Treatment	Average yield per acre for ten years
	bush. lbs.
Fall cultivate (disk), plough 6 inches early June	34 18
Skim plough in fall, plough 6 inches early June	34 38
No fall cultivation, plough 6 inches early June	33 47

While there is a slight increase from the fall cultivation it is so small as to be negligible. The two methods of cultivation have shown no difference.

As fall cultivation is usually recommended as a method of controlling wild oats, and as there are no wild oats on the land used, this test is perhaps hardly a fair test of the practice in question. In farm practice where wild oats flourish, this method seems to have been successful in inducing increased germination of the weed seeds, the plants from which are killed by the regular fallow ploughing. However, considered as a part of the fallow apart from wild oat eradication, this experiment shows that such fall cultivation does not increase the crop to any appreciable extent.

CULTIVATION OF SUMMER-FALLOW

The question of how to cultivate the summer-fallow, including what implements to use, when and how frequently to use and other closely related points, is an extremely important one. It is not, however, one that lends itself readily to experimental trials. So many disturbing factors enter into such a test, such as variations in soil, variations in the condition of the same soil at different times and variations in weed infestation, that general observations rather than direct statistical comparisons are the best that can be offered. In any case a study of the reports of this Farm does not bring to light any figures bearing on the subject.

Nevertheless, the observations of the superintendents past and present and some trials that have been made that have not been reported in the form of concrete crop yields do lead to some definite opinions on the subject.

In the first place, the importance of thoroughness of cultivation can hardly be over-emphasized. This thoroughness of cultivation should be directed toward weed control, both because the summer-fallow is the opportunity to eradicate these weeds, and because weeds and any other growth are the chief and almost the only cause of loss of moisture. The soil mulch as a means of prevention of evaporation, once considered to be very important, has been shown by American investigators to be of very minor importance. Moisture is removed from the soil by the action of growing plants and only to a very limited degree by capillary movement in the soil. Accordingly, thoroughness in cultivation should be directed toward prevention of plant growth rather than to attaining any particular ideal of tilth.

It is obvious that to attempt to say how many operations of cultivation are necessary to attain that thoroughness is futile. It is entirely a matter of observation and common sense. The amount which is adequate to keep one piece of land clean may be entirely inadequate for another, and what may be required in a third to eradicate, say, sow thistle, may lead to dangerous over-pulverization in a fourth.

The problem of soil drifting enters into this discussion as a serious complication. How is thorough cultivation to be accomplished without bringing the soil to a condition where it will drift the next spring if high winds come? In some soils it is impossible, as the fibre has been worked out, so that the only remedy is to change the whole system and get fibre restored. But in many soils the control of drifting may be attained by the methods used in cultivating the fallow. In this connection the newer knowledge of the lesser importance of the soil mulch helps out. It is not necessary to reduce the surface of the fallowed soil to a fine tilth. So long as the weeds are kept from growing, a lumpy surface is as good as a smooth one and much less conducive to blowing. This surface may be obtained by choosing the right implements and by avoiding cultivation at the wrong time. In this connection, the wrong time for soils in danger of blowing is just the right time for cultivation against couch grass. The drier the surface, the greater the danger of over-pulverization of drift soils, but the better the prospects of killing couch grass roots.

CULTIVATION IMPLEMENTS FOR THE SUMMER-FALLOW

In the early years the disk harrow was one of the chief implements of summer-fallow cultivation; and very suitable it was for cutting up the tough prairie sod. But its day as an implement of general use on summer-fallows has gone by. It is too pulverizing in its action and hence should not be used where soil drifting is a danger. It is not as efficient as other implements in cutting off weeds, and except under special conditions it should be kept off the summer-fallow. Its best use is in cutting up sods. Where couch grass or other grass

is so thick on land that is to be fallowed that a cultivator cannot go through it, then the disk harrow is the best implement to chop it up so that other implements can be then used.

The most generally used and the best all-round implement for summer-fallow cultivation so far as present knowledge shows is the cultivator, sometimes called the duck-foot cultivator, though narrow shares can be used on the same implement. This cultivator is made in a good many different styles and under several names, but the general feature of all types is the cutting share or blade held in the ground by an upright shank. There are spring-toothed and stiff-toothed types; the most common is the stiff-toothed with a patent release that lets go when an immovable object is struck. For most work this type is most satisfactory, as it holds the share rigidly to its work. Wide shares are used for ordinary cultivation and weed cutting, narrow ones are put on for root pulling of grasses and perennials. This implement has quite rightly replaced the disk harrow on the summer-fallow as it is more efficient in cutting off weeds, and does not loosen up the soil so much.

The drag harrow at one time was used extensively on fallows. On soils subject to blowing it has been almost entirely eliminated, and quite rightly so, as it is essentially a pulverizing implement. It may be used to advantage in a limited way following the narrow-tooth cultivator in dragging out grass roots.

The rotary-rod weeder has been introduced in recent years. The cultivating device consists of a square rod running horizontally under the surface of the soil and revolving so that the front edge turns upward. This is claimed to be more efficient than any other cultivator in accomplishing the work of cultivation without pulverization of the surface, and is therefore advocated for districts where soil drifting is a menace. This implement has been tried out at Brandon. It is very efficient in pulling and cutting weeds wherever conditions are suitable for its operation. It will not work in sods nor in dense masses of weed roots, but if the latter are loosened up with another implement it will pull the plants effectively. With regard to its claimed advantage in preventing soil drifting, so far as observations at Brandon indicate, it was not found much better, if any, than the ordinary cultivator.

The cyclone weeder is an implement with a cultivating device consisting of long knife-like blades, sloping backward as they cut, fastened below a flat platform. On account of the greater length of blade and the fact that the blades overlap on each other, greater efficiency in weed cutting is claimed for it than that for the ordinary cultivator. This claim it can make good if soil tilth conditions are ideal, but it is easily clogged up where there are any weeds in thick bunches, roots or trash that can gather on the blades. For a field in mellow condition with scattered weeds to cut, it does beautiful work, but in the more difficult spots, which occur mostly on any summer-fallow, it is helpless, as it clogs up and floats over the top.

The use of the soil packer as a tillage implement on summer-fallow will be dealt with elsewhere.

SUMMER-FALLOW SUBSTITUTES

From the first seasons when corn was grown as a fodder crop and wheat sown after it, it has been observed on this Farm that corn growing was an excellent preparation for wheat growing. The inter-tillage which was possible while the corn was growing permitted that crop to act as a substitute for summer-fallow. Other inter-tilled crops such as potatoes and field roots were seen to give similar results in a greater or lesser degree. Until 1921, however, no experiment was started for the purpose of making a direct comparison between wheat grown on summer-fallow and that following the various inter-tilled crops.

However, the experiment in crop rotations described farther on in this bulletin has given indirectly a very good test of the value of corn as a summer-fallow substitute. Two rotations situated near each other on land of the same character have on one a field of wheat each year on summer-fallowed land and on the other a field of wheat on corn land. While the rest of the rotation may have some effect on the wheat yields, the two are enough alike in the other crops included in the rotation that this influence should be slight. Each rotation is manured once in six years, and the two fields in question are always sown at practically the same date. From 1914 to 1921 this comparison has been made each year, with the following results:—

WHEAT FOLLOWING CORN AND FALLOW

Year	Yield per acre on corn land	Yield per acre on fallow land
	bush.	bush.
1914	31·0	32·4
1915	40·0	32·2
1916	15·0	9·3
1917	28·2	21·3
1918	43·3	50·7
1919	29·5	24·1
1920	28·8	20·9
1921	27·3	24·4
Average for nine years	27·0	23·9

WHEAT ON CORN AND SUNFLOWER LAND IN A DRY SEASON

(Right) Wheat on the corn land yielded 34 bus. 40 lb. per acre.
(Left) Wheat on sunflower land yielded 19 bus. 20 lb. per acre.

In 1921 an experiment was started for the purpose of comparing different kinds of inter-tilled crops. The plots were fallowed or sown to these crops in 1921 and sown with Marquis wheat in 1922. The same experiment has been repeated in 1922 and 1923. The average for the two years is as follows:—

SUMMER-FALLOW SUBSTITUTES

Treatment	Average yield of wheat per acre—two years
	bush. lbs.
Corn instead of fallow	32 50
Sunflowers instead of fallow	24 30
Mangels instead of fallow	30 40
Potatoes instead of fallow	37 ..
Bare fallow	36 15

In this test it will be observed that the wheat following corn has yielded within 3.5 bushels per acre of that from summer-fallowed land.

In addition to the good showing made by corn in these tests in regard to the yield of wheat, there are other considerations in its favour. It produces a crop which ripens several days earlier than that on summer-fallow. In rust seasons it escapes disease much better on account of its earliness. The yields of 1916 are an illustration of this. The straw is lighter, less subject to lodging and less wasteful of binder twine. But the chief advantage is found when the question is viewed from the standpoint of cost of production. In 1920 wheat grown on corn land cost 76 cents per bushel to produce, as compared with $1.53 on summer-fallow. In 1921 wheat on corn land cost 70 cents per bushel to produce and $1.30 per bushel on summer-fallow. This difference is due to the production of a valuable crop during the season of cultivation instead of having two year's overhead expenses in producing the crop of wheat.

The 1922 and 1923 yields show potatoes to be even more efficient than corn as a summer-fallow substitute, and general observations tend to corroborate this result. However, the practical use of this information in Manitoba is greatly limited, as very few farmers are prepared to handle more than a little patch of potatoes. Where it is found practical to grow potatoes in a more extensive way, the land on which they have grown will be found to be admirably suited to wheat production the next year.

Field roots are heavier users of moisture than corn or potatoes and are less efficient as summer-fallow substitutes.

Sunflowers have been followed in the above test by an average of over 8 bushels per acre less wheat on the average of the two seasons than following corn. Sunflowers appear to be much heavier users of moisture and plant food than the other crops in this test and are decidedly less suited to use as a summer-fallow substitute. Trials on field areas with oats as the following crop in several different seasons have given corroborative results, in that the oats after corn very materially outyielded those after sunflowers.

RAPE AND OTHER CROPS PASTURED AS SUMMER-FALLOW SUBSTITUTES

From 1912 to 1923, inclusive, a test has been conducted in which the growing of rape and pasturing it off has been tried out as a summer-fallow substitute. The average yields for eleven years (1916 omitted) have been as follows:—

Treatment	Average yield per acre 11 years
	bush. lbs.
Summer-fallow	34 59
Rape pasture	25 49

In 1921 this experiment was widened to include a plot of mixed cereals used for pasture instead of rape. The crop from these plots in 1922 showed 8 bushels more yield per acre from the wheat following mixed cereals than when following rape, but both were much below the bare fallow. The plot on which rape was sown has only in one of the eleven years given good results.

This experiment would seem to indicate that where the conservation of moisture is as important as it is here at Brandon, the pastured fallow, so-called, cannot be considered as a satisfactory substitute for the usual bare or cultivated fallow. While the growing of annual pasture crops will doubtless often be needed for live stock raising, and will be a wise policy in many instances, such cannot be looked upon as a fallow preparing the land for wheat, but rather as a crop in itself, drawing moisture from the soil.

From the standpoint of weed eradication, the pastured fallow is a good substitute for bare fallow for the control of edible annuals such as wild oats, but is of no value against perennial weeds such as grass or thistles and of very doubtful use against unpleasant-tasting annuals such as stinkwheat which is not eaten by the live stock pasturing the land.

CULTURAL EXPERIMENTS

TREATMENT OF STUBBLE LAND

When one wheat crop follows another in the rotation the question of how to handle the stubble land in preparation for the second crop is one deserving of attention. Is it better to plough in the spring or in the fall or not plough at all; and if not, what shall take the place of the ploughing? Since 1891 there has been more or less experimentation on this subject, and since 1911 a fairly complete experiment has been operating.

From 1891 to 1899 some comparisons were made between fall and spring ploughing, and between one or both and drilling in stubble without ploughing. In only two seasons did all three enter into the test. The results obtained in these seasons are as follows:—

Fall vs. Spring vs. No Ploughing

Year	Yield per acre on fall ploughing		Yield per acre on spring ploughing		Yield per acre on stubble (unploughed)	
	bush.	lbs.	bush.	lbs.	bush.	lbs.
1891	27	28	20	8	..	..
1892	16	50	28	10	..	..
1894	..	..	23	..	26	20
1895	18	40	24	10	..	..
1896	..	..	21	40	17	30
1897	26	40	29	40	23	40
1898	31	10	35	..	36	20
1899	38	10	36	40	..	..
Average of six seasons in which fall and spring ploughing are compared	26	29	28	58	..	..
Average of four seasons in which spring ploughing and drilling in stubble are compared	..	..	27	20	23	27

The experiment planned in 1911 covered more ground. The following table shows the tests included and the results obtained during the seven years in which crops were harvested from these plots.

TREATMENT OF CORN LAND FOR WHEAT

The growing of wheat on corn land has been found to be a successful practice. Up to 1923 little had been done in experimental work on the handling of the corn land for wheat growing. In 1895 a test was made comparing spring ploughing with no ploughing of corn land. The wheat on spring ploughed corn land yielded 32 bushels and 20 pounds per acre and that on unploughed 39 bushels 30 pounds per acre. An experiment was started in 1923 covering wider ground, and more results should be available for future reports.

However, opportunities for observation have been presented in the general farm operations and the writer has formed a decided opinion on the subject. This is, that it is best not to plough corn stubble in preparation for wheat, provided that the corn land has been well cultivated and kept free from weeds. The seed bed conditions found in such a corn-field are better than can be obtained again after it has been ploughed. All it requires is some surface cultivation with disk or cultivator and harrow to have ideal conditions for sowing wheat. The corn stubble is less in the way standing upright in place than it is after it has been overturned by the plough. Of course, if weeds, and especially grass, are present, and have not been cleaned out by the cultivation of the corn, then ploughing is necessary.

TREATMENT OF WHEAT STUBBLE

TREATMENT OF WHEAT STUBBLE (1)

Treatment	Average yield per acre for seven years	
	bush.	lbs.
Plough in fall	24	6
Plough in spring	26	40
Plough in fall and pack after ploughing	25	23
Plough in spring, pack after seeding	23	36
Disc at cutting time and fall plough	25	17
Disc at cutting time and spring plough	24	13
No ploughing, disk in fall	23	43
No ploughing, burn stubble and disk in fall	25	12
Burn stubble and plough in fall	24	42
No ploughing, burn stubble in spring	25	44

In 1919 this experiment was again reorganized and continued in slightly different form. The average results for the three years since that time are as follows:—

TREATMENT OF WHEAT STUBBLE (2)

Treatment given	Average yield per acre for three years	
	bush.	lbs.
Plough in fall (early September)	27	57
Plough in fall (mid October)	25	47
Plough in spring	28	7
Cultivate at harvest time and plough mid October	28	..
Cultivate at harvest time and plough in spring	26	13
Cultivate in October and plough in spring	26	33
Burn stubble in spring and plough in spring	27	7
No ploughing, burn stubble and disc in spring	29	7
No ploughing, cultivate in spring	28	..

These experiments are difficult to translate into any definite rule of procedure. Spring ploughing on the whole has given slightly larger returns than fall ploughing. But when the advantage of fall ploughing from the standpoint of efficiency in farm management is considered, and the advantage gained by the early seeding which is made possible by fall ploughing, it will have to be granted that the increase in yields from spring ploughing is insufficient.

In the experiment of the last three years, early fall ploughing has given somewhat better results than late fall ploughing, though the difference is hardly great enough to justify any definite conclusions.

Cultivation in advance of ploughing has not given any increased yield.

The experiments would appear to show fairly clearly that ploughing is not an essential part of the successful handling of stubble land. In all three experiments, methods which have substituted disking or cultivating for ploughing have given almost as good or in some cases better results than ploughing. It must be borne in mind, however, that the land used was reasonably clean and that consequently the preparation of a seed bed was the chief object of cultivation, and only in a very minor way did weed control have to be considered. Where such conditions prevail, it has been fairly clearly shown that ploughing is not necessary to the preparation of a first-class seed bed. But where weeds, and particularly grasses, are to be controlled, practical experience would indicate that ploughing is necessary.

Stubble burning has not shown any harmful effect as yet, but as it destroys vegetable fibre its ultimate effect must be injurious. Early experiments conducted in the '90's gave a higher yield from burned stubble land than from unburned.

CULTIVATION AFTER FALL PLOUGHING

In 1893 an experiment was conducted in which harrowing, rolling and a combination of both were tried following the fall ploughing. Both treatments reduced the yield below that on land only ploughed in the fall, and the combination of the two reduced it the most. In has been the common experience since that time that fall ploughing is best left rough during the winter to catch and hold the snow as much as possible.

TREATMENT OF SOD LAND

DEPTH OF PLOUGHING

From 1912 to 1920, inclusive, an experiment was carried on in which ploughing sod at three different depths in preparation for wheat growing was tried. The sod used was a mixture of tame grasses and clovers. In each season the sod used for the experiment was two years old, so that old, tough, dry sods were not covered by the test. The results obtained are as follows:—

DEPTH OF PLOUGHING SOD

Depth of Ploughing	Average yield of wheat per acre for eight years	
	bush.	lbs.
3 inches	30	5
4 "	30	31
5 "	32	..

While the difference is not very conclusive, it is in favour of the 5-inch ploughing. It was found to be difficult to turn the sod over properly at shallower depths and more grass escaped killing. Greater depths than 5 inches for sod ploughing are not practicable as they require too much power and the sod does not rot as readily when buried deeper.

BREAKING SOD

Wheat on summer breaking after taking hay crop. Note clean stand of grain.

BREAKING SOD

(Left) Wheat following flax on spring breaking.

(Right) Wheat following wheat on spring breaking. Note the large amount of alfalfa and grass persisting. The excessive growth of straw is due to the wet season.

METHODS OF BREAKING SOD LAND

From 1914 to 1920, inclusive, an experiment was conducted in which different methods of breaking sod land were compared. The test included spring breaking followed by immediate seeding to three different grain crops, early summer breaking followed by bare fallow, midsummer breaking after taking off the hay crop and followed by different treatments, and fall breaking. The sod was a mixture of tame grasses and clovers including alfalfa which latter gave the real test as to the efficiency of the method. The sod in each test was four years old. The results obtained are as follows:—

METHODS OF BREAKING SOD

Treatment	Crop in breaking year		Average yield of wheat per acre in test year seven-year average
	Kind	Average yield per acre for seven years	
		tons lbs.	bush. lbs.
Plough July after hay removed, 5 inches deep, pack and disk, repeat diskings	Hay	1 1,814	23 6
Plough in October, pack and disk	"	1 1,814	22 10
Plough July 3 inches deep, backset Sept., 5 inches	"	1 1,814	27 36
Stiff tooth rip July 5 inches, plough Sept. 5 inches	"	1 1,814	23 21
		bush. lbs.	
Spring plough 5 inches, seed same spring to wheat	Wheat	17 26	20 40
Spring plough 5 inches, seed same spring to flax	Flax	6 21	22 5
Spring plough 5 inches, seed same spring to peas	Peas	14 32	23 3
Plough May 15, work as summer-fallow	None	.. ..	32 51

The summer-fallow treatment was most effective in cleaning out the grass and alfalfa and gave the largest yield of wheat in the test year. However, as this was accomplished by the complete loss of crop in the treatment year the cost was too great. Next in efficiency in killing grass came the July ploughing. Where this was followed by the September backsetting the results were best, but the July ploughing with repeated diskings also gave good results. The fall breaking and the cropped spring breaking were much less effective in destroying the grass and alfalfa, and are not recommended.

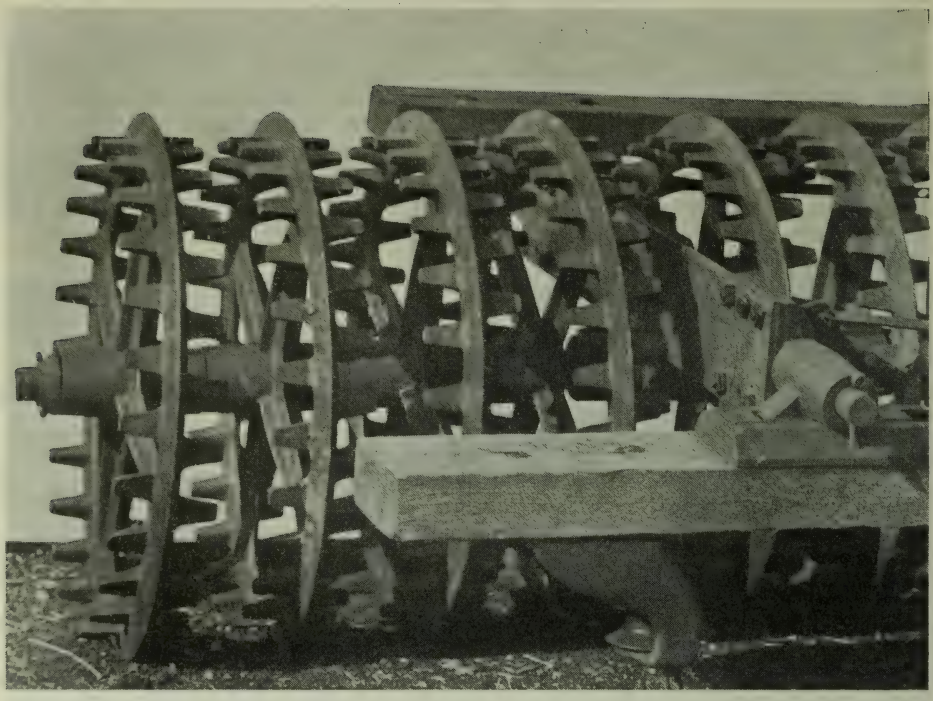
In 1920 this experiment was reorganized, eleminating the stiff-tooth rip which was found to be impractical, and substituting oats for peas on spring breaking, as the peas made the poorest showing in keeping down weeds and grass. The results since the change in the experiment tend to confirm the conclusions already stated.

PREPARATION OF SEED BED

PACKING

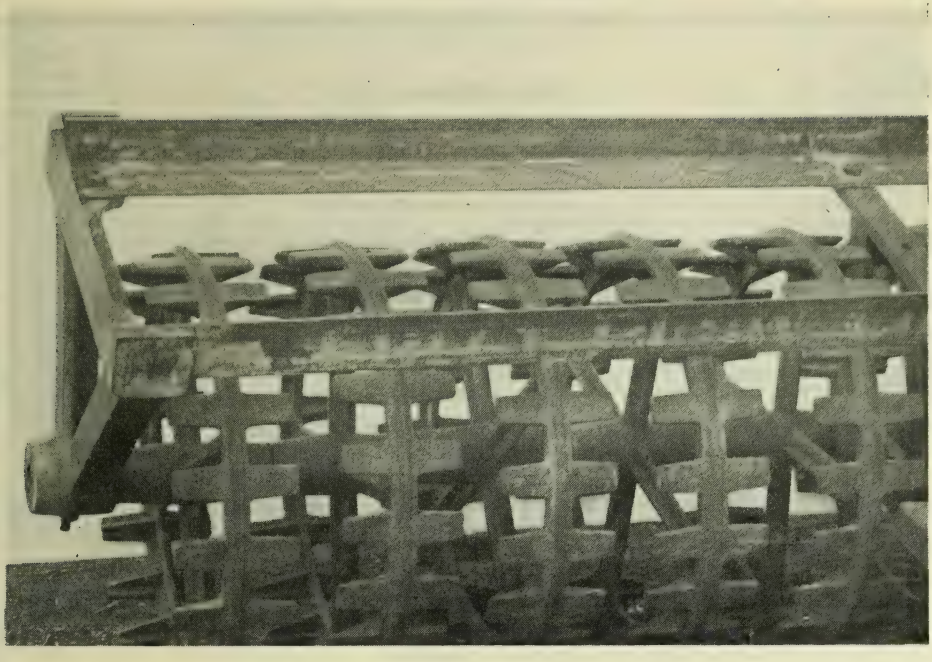
In 1892, 1894, and 1898 tests were made in rolling land for wheat. The smooth roller was the only kind of implement of this kind available at that time. In 1892 no apparent advantage was obtained by rolling, but in each of the other years about 1·5 bushels increased yield came from the plots which had been rolled. However, the use of the roller died out in the years that followed, probably due to its pulverizing effect and the increased danger of soil blowing.

From about 1907 on, a great interest was awakened in soil packers. The work of H. W. Campbell, of Nebraska, directed attention to the subsurface packer, which was built for the purpose of applying the pressure to the lower part of the seed bed rather than to the surface thus firming the soil about the



The combination packer.

The subsurface packer.



The surface packer.

seed and leaving a loose mulch on the surface. The correctness of this theory was very generally accepted throughout Western Canada and the advocacy of the packer as a necessary implement of agriculture became widespread. In order to obtain definite and reliable data on this subject a comprehensive set of experiments was inaugurated at Brandon in 1911. Three types of packers were included in the test: first, the subsurface packer composed of V-shaped wheels; second, the surface packer, the packing wheels of which had flat surfaces, but did not compact all the surface and consequently left the surface rough; and third, the combination packer which was half way between the other two in type. These three implements were tried in all the different methods that were considered at all practical. The results obtained in six years in this test are as follows:—

PACKING ON SUMMER-FALLOW

Plot No.	Treatment given	Yield per acre six-year average	
		bush.	lbs.
1	No packing	35	58
2	Packed with surface packer after seeding	38	18
3	Packed with surface packer after seeding, harrow after packing	35	37
4	Packed with surface packer after seeding	38	20
5	Packed with surface packer after seeding, harrowed after packing	35	20
6	Packed with combination packer after seeding	36	57
7	Packed with combination packer after seeding, harrowed after packing	37	9
8	Packed with surface packer both before and after seeding	38	30
9	Packed with subsurface packer both before and after seeding	39	3
10	Packed with combination packer both before and after seeding	38	30
11	Packed with surface packer before seeding	39	33
12	Packed with subsurface packer before seeding	38	33
13	Packed with combination packer before seeding	36	50
14	No packing	36	30
15	Packed with surface packer right after ploughing summer-fallow	36	18
16	Packed with subsurface packer right after ploughing summer-fallow	38	17
17	Packed with combination packer right after ploughing summer-fallow	37	48
18	Packed with surface packer right after ploughing summer-fallow and again in spring after seeding	37	52
19	Packed with subsurface packer right after ploughing summer-fallow and again in spring after seeding	37	18
20	Packed with combination packer right after summer-fallow and again in spring after seeding	38	10
21	No packing	37	18
22	No packing, grain harrowed when 6" high	35	18
23	Packed with surface packer when grain is 6 inches high	36	20
24	Rolled with smooth roller when grain is 6 inches high	35	35
25	No packing	36	3

SUMMARIES OF RESULTS ON SUMMER-FALLOW

—	Average yield of wheat for six years	
Kind of Packer	bush.	lbs.
Surface packer (average of plots 2, 3, 8, 11, 15 and 18)	36	21
Subsurface packer (average of plots 4, 5, 9, 12, 16 and 19)	37	49
Combination packer (average of plots 6, 7, 10, 13, 17 and 20)	37	34
No packer (average of plots 1, 14, 21 and 25)	36	27
Time of Packing		
After seeding (average of plots 2, 4 and 6)	37	52
Before seeding (average of plots 11, 12 and 13)	38	19
Before and after seeding (average of plots 8, 9 and 10)	38	41
At time of ploughing summer-fallow (average of plots 15, 16 and 17)	37	28
At time of ploughing summer-fallow and after seeding (average of 18, 19 and 20)	37	47
Packer versus Harrow as Last Implement		
Packer applied last (average of plots 2, 4 and 6)	37	52
Harrowed after packing (average of plots 3, 5 and 7)	36	2

PACKING ON SPRING PLOUGHING

Plot No.	Treatment given	Yield of wheat per acre, six-year average	
		bush.	lbs.
1	Packed with subsurface packer before seeding	32	29
2	Packed with surface packer before seeding	30	35
3	Packed with combination packer before seeding	30	53
4	Packed with subsurface packer before and after seeding	33	24
5	Packed with surface packer before and after seeding	31	20
6	Packed with combination packer before and after seeding	32	17
7	No packing	31	55
8	Packed with surface packer after seeding	31	30
9	Packed with subsurface packer after seeding	31	37
10	Packed with combination packer after seeding	30	42
11	No packing	31	10

SUMMARIES OF RESULTS ON SPRING PLOUGHING

——	Yield of wheat per acre, six-year average	
Kind of Packer	bush.	lbs.
Surface packer (average of plots 2, 5 and 8)	31	12
Subsurface packer (average of plots 1, 4 and 9)	32	30
Combination packer (average of plots 3, 6 and 10)	31	17
No packer (average of plots 7 and 11)	31	32
Time of Packing		
Before seeding (average of plots 1, 2 and 3)	31	19
After seeding (average of plots 8, 9 and 10)	31	26
Before and after seeding (average of plots 4, 5, 6)	32	24

PACKING ON FALL PLOUGHING

Plot No.	Treatment given	Yield of wheat per acre, six-year average	
		bush.	lbs.
12	No packing	29	15
13	Packed with subsurface packer in the fall	30	17
14	Packed with subsurface packer in spring before seeding	29	25
15	Packed with subsurface packer in spring after seeding	30	10
16	Packed with surface packer in fall	29	57
17	Packed with surface packer in the spring before seeding	29	10
18	Packed with surface packer in the spring after seeding	29	47
19	Packed with combination packer in fall	29	50
20	Packed with combination packer in spring before seeding	30	17
21	Packed with combination packer in spring after seeding	30	32
22	No packing	30	18
23	Packed with surface packer in the fall and in spring after seeding	31	8
24	Packed with subsurface packer in the fall and in spring after seeding	29	43
25	Packed with combination packer in the fall and in spring after seeding	31	38

—	Yield of wheat per acre, six-year average	
Kind of Packer	bush.	lbs.
Surface packer (average of plots 16, 17, 18 and 23)	30	..
Subsurface packer (average of plots 13, 14, 15 and 24)	29	54
Combination packer (average of plots 19, 20, 21 and 25)	30	34
No packer (average of plots 12 and 22)	29	46
Time of Packing		
In fall (average of plots 13, 16 and 19)	30	1
In spring before seeding (average of plots 14, 17 and 20)	29	37
In spring after seeding (average of plots 15, 18 and 21)	30	3
In fall and in spring after seeding (average of 23, 24 and 25)	30	50

These results do not show any advantage from the use of the packer. Where there are slight variations in average yield they are so small as to have no significance. It is of interest in this connection to note that similar results have been obtained on practically all the other prairie Experimental Farms. It would appear to be proven that the packer is unnecessary as an implement for regular use in the preparation of the land for wheat growing. This does not of necessity prove that it is never useful. It is quite possible that for special circumstances where the condition of the land is abnormally open or loose that the use of a packer may be justified. The tests cover most ordinary cases in the growing of wheat and in none of them is any consistent improvement in yield shown from the use of the packer.

Considering the tremendous investment in such implements by western farmers, these figures are most important.

TYPES OF DRILLS

For five years, 1890 to 1893 inclusive and 1895, a test was conducted in which seeding grain with a drill was compared with seeding it with a broadcasting machine. At that time the broadcasting machine was generally used and the drill was an innovation. What was called the common drill (now known as hoe drill) was also compared with a press drill in the same test. The average yields per acre obtained were as follows:—

	bush.	lbs.
Common drill (hoe)	33	31
Press drill	33	35
Broadcasting machine	27	42

The seed sown by the drills gave consistently better results than that sown broadcast, but no appreciable difference in results between the two types of drills could be found.

In 1897 and 1898 a test was made in which a hoe drill and a shoe drill were compared. The average returns were:—

	bush.	lbs.
Hoe drill	26	55
Shoe drill	26	30

The broadcast machine was included in 1898 and gave 7 bushels less than the lower of the two drills.

In 1893 a test was made between a shoe drill and a disk drill, then a new introduction. The difference in yield between the two was only 30 pounds per acre.

No comparative tests of drills have been made in recent years. The double disk type of drill has been in general use on the Farm for many years now and is found satisfactory.

CULTURAL TREATMENT TO CONTROL RUST

From 1917 to 1923 an experiment was conducted in which an effort was made to find out what methods in the handling of soil and crop might be employed to reduce the injury from rust attacks when such come. Among the tests were included thick vs. thin seeding, early vs. late seeding, the influence of the application of different types of fertilizers, and the influence of different types of crop preceding the wheat, as compared with bare fallow.

The most decisive results have come from the dates of seeding. In each season that rust has appeared, the early wheat has had less of it at the time of ripening. The 1923 results are the most striking as in that season came the worst rust attack of the test. The 1923 results are as follows, Marquis being the variety used:—

Dates of Sowing in Season of Rust

Date sown	Date ripe	Per cent rust at harvest	Weight per bushel	Yield per acre	
			lbs.	bush.	lbs.
April 30	Aug. 3	25	61·5	31	40
May 10	" 7	65	57·0	25	..
May 20	" 12	100	53·0	20	..
May 30	" 17	100	50·0	12	20

The April 30 seeding produced a normal crop of wheat, virtually unaffected by rust. This season, 1923, was a very late one; the spot used for this test was the only one fit to sow at that date. Had it been possible for the 1923 crop to have been sown in April instead of May it seems altogether likely that the loss from rust would have been reduced to insignificant proportions. In this test, the May 10 seeding, though only 3 days later in ripening than the April 30, was decidedly a rusted crop weighing only 57 pounds per bushel. The later sowings were much worse.

Thick seeding has produced a slightly earlier maturing crop than thin seeding, and thus has been less affected by rust.

Wheat following another crop of grain or corn has been less subject to rust than has wheat on fallowed land. Both these results appear to be brought about by a reduction of the moisture available to each plant. This makes an earlier and less rank growth and consequently gives greater immunity from rust.

The application of barnyard manure and nitrate fertilizer tended to increase the amount of rust while a phosphatic fertilizer had no effect.

Generally speaking, any cultural method that increases moisture supply and induces rank growth or late maturity increases the danger of rust attack. The treatments which make for large yields in normal seasons mostly make for heavy rust attacks when rust comes. Exceptions to this, however, are early sowing and sowing on corn land, which appear advantageous in any case.

CUTTING AT DIFFERENT STAGES OF RIPENESS

In the early years of wheat growing in Manitoba, loss by damage from frost was common and in order to escape this, cutting the crop before it was ripe became a common practice. In 1893 and 1894 a test was made to determine what stage was the best at which to cut wheat. The Red Fife and White Connell varieties were used for the test. The average results with the two varieties for two years are as follows:—

STAGES OF MATURITY

Stage at which cut	Average weight per measured bushel	Average yield per acre	
	lbs.	bush.	lbs.
Early milk	50·4	16	45
Late milk	55·9	21	25
Dough	59·5	28	5
Ripe, yellow	61·2	28	30

The observations made on this experiment were: "Wheat cut before the dough stage loses heavily both in yield and weight per bushel. Although it is preferable to allow the grain to harden before cutting, there is very little shrinkage after the dough stage is reached or within, say, a week of ripening."

In 1904 and 1923 when severe rust attacks were being experienced, tests were made in regard to the time of cutting rusted wheat. In 1904 Red Fife wheat was used for the test and cuttings were made at four different stages.

CUTTING RUSTED WHEAT AT DIFFERENT STAGES
(Red Fife 1904)

Stage when cut	Condition of straw	Date	Weight per measured bushel	Yield per acre	
			lbs.	bush.	lbs.
Milk	Quite green	Aug. 30	54	25	40
Dough	Greenish	Sept. 6	54	26	..
Nearly hard	Nearly ripe	Sept. 13	54	24	40
Quite hard	Quite ripe	Sept. 22	54	24	20

In 1923 a similar test was made with Marquis and Ruby varieties. The plots used were sown late (May 16) so that the rust affected them with the full force of its attack. The results obtained are as follows:—

CUTTING RUSTED WHEAT AT DIFFERENT STAGES
(Marquis 1923)

Stage when cut	Date of cutting	Per cent rust infection	Weight per bushel	Yield per acre	
			lbs.	bush.	lbs.
Early dough	Aug. 1	75	48·0	15	50
Early to medium dough	" 3	85	48·0	18	50
Medium dough	" 6	95	48·5	20	..
Medium to firm dough	" 8	100	48·75	20	..
Firm dough	" 10	100	49·0	21	..
Ripe	" 13	100	50·0	21	..
Dead ripe	" 15	100	49·75	20	48

CUTTING RUSTED WHEAT AT DIFFERENT STAGES
(Ruby 1923)

Stage when cut	Date of cutting	Per cent rust infection	Weight per bushel	Yield per acre
			lbs.	bush. lbs.
Medium dough	Aug. 1	70	53	18 20
Medium to firm dough	" 3	80	55	24 ..
Firm dough	" 6	95	53	21 20
Firm dough to ripe	" 8	100	54	22 ..
Ripe	" 10	100	53	18 20
Dead ripe	" 13	100	54	19 ..

The stand of Ruby wheat in 1923 was uneven, which may account for the irregular results.

These results are of necessity inconclusive, but so far as they indicate anything, it would appear to make little difference whether rusted wheat be cut in the dough stage or left to ripen.

MANURES AND FERTILIZERS

BARNYARD MANURE

From 1892 to 1895 a test was conducted for the purpose of determining the value of barnyard manure when applied for wheat. Both rotted and fresh manure were used. They were applied at the rate of 20 tons per acre. The average yields per acre from these treatments were:—

	bush.	lbs.
Fresh manure	22	37
Rotted manure	21	35
No manure	21	7

The increase in yield was practically nil. It is reported, however, that the crop was somewhat earlier on the land which had received the manure. At that time the land had not produced many crops and the rate per acre seems excessively high, judged by later experience.

In 1913 another experiment was started in which different methods of applying barnyard manure were compared. Rotted manure was used in these tests except in one instance, and the rate of application was 12 tons per acre. The manure was applied on land which had grown one crop of wheat after a summer-fallow and which was again sown to wheat. Two treatments were also given on summer-fallowed land. The average results obtained from a six years' test are as follows:—

APPLYING BARNYARD MANURE

Treatment	Average yield per acre for six years
	bush. lbs.
To affect second crop after summer-fallow	
Apply in winter green manure, disk in	24 38
Top dress with spreader after seeding	28 12
Apply in fall and plough in	29 10
Apply in spring and plough in	33 15
No manure	25 53
No manure, stubble disked not ploughed	26 40
No manure, stubble burned, ploughed	26 20
To affect crop on fallow	
Apply in winter green manure, disk in	37 55
Top dress with spreader after seeding	38 35
No manure	37 13

The application of barnyard manure on stubble land has had an effect in increasing the yield of wheat in this experiment. The application on summer-fallowed land has had practically no effect. The ploughing under of the manure has given better results than surface applications, and ploughing under in the spring has excelled ploughing under in the fall.

In 1921 this experiment was rearranged so as to bring out more clearly the effect of the different factors which might influence results. Separate tests were made on the method and time of application on both spring and fall ploughing, the quantity of manure and rotted versus fresh. In all cases stubble land which had grown one crop of wheat was used for the test. Rotted manure was used except where otherwise stated and 8 tons per acre was the quantity used except in the test on quantities. Results from this experiment have been obtained in 1922 and 1923 and are as follows:—

Method and Time of Application on Fall Ploughing

Treatment	Average yield per acre, two years	
	bush.	lbs.
Apply in fall and plough in	29	20
Apply in late fall after ploughing, disk in in spring	27	40
No manure	26	30
Apply in spring and disk in before seeding	27	10
Top dress after crop is up	29	..

Method and Time of Application on Spring Ploughing

Treatment	Average yield per acre, two years	
	bush.	lbs.
Apply late fall, plough in in spring	30	20
Apply in spring and plough in	30	20
No manure	26	40
Apply in spring after ploughing, disk in before seeding	26	50
Top dress after crop is up	27	30

Rotted vs. Fresh Manure (on Fall Ploughing)

Treatment	Average yield per acre, two years	
	bush.	lbs.
Rotted manure, apply in fall and plough in	31	..
Fresh manure apply in fall and plough in	30	30
No manure	29	40
Rotted manure, top dress after crop is up	30	40
Fresh manure, top dress after crop is up	31	10

Rates of Application (Rotted Manure on Fall Ploughing)

Treatment	Average yield per acre, two years	
	bush.	lbs.
6 tons per acre	32	..
8 tons per acre	34	..
No manure	26	..
10 tons per acre	30	30
12 tons per acre	29	30

Again in this experiment the ploughing-in of manure has given better results than the surface working. Where this method has been followed, increases in yield have been obtained that would appear to be worth while. Spring ploughing-in of manure has again given slightly better results than fall ploughing-in, though whether sufficiently greater to justify leaving the work till spring is doubtful. It is interesting to note that late fall application with spring ploughing-in has given equal results with spring application. This method with the work being done after freeze-up might allow the work of spreading the manure to be done with least interference with farm work.

Perhaps the most striking result of the last test is the low returns from the heavier applications of manure. Two years' results are not enough on which to base conclusions, but it is significant that maximum results were obtained in both years from the 8 ton application and that heavier applications were not only wasted but actually depressed the yields.

GREEN MANURING

In 1898 and 1899 a comprehensive test of the ploughing-in of crops for green manure was made. Ten acres were divided into 20 half-acre plots. Five plots of summer-fallow were interspersed throughout the block as a check and also four plots of oats which were ripened and harvested. The other plots were sown to mammoth red clover, common red clover, alsike, alfalfa, sweet clover, tares, rape, buckwheat, and brome grass. These crops were ploughed under when in blossom except rape and brome grass which were turned under in August. The second year of the experiment (1899) wheat was sown on all the plots with the following result:—

Green Manuring, 1898–1899

Treatment, 1898	Yield of wheat, 1899	
	bush.	lbs.
Summer-fallow (average of five plots)	34	30
Leguminous crop ploughed under (average of six plots)	31	..
Other crops ploughed under (average of five plots)	30	43
Crop of oats harvested (average of four plots)	25	37

From 1913 to 1922 an experiment was conducted in which the effect which the ploughing under the peas and vetches has on the following wheat crop was investigated. This green manuring takes the place of summer-fallow in the rotation, and two bare fallow plots unmanured and one bare fallow plot manured with barnyard manure are included in the test as checks. The land for green

manuring is ploughed in the spring as early as possible, and the seed sown as soon as possible thereafter. One plot of peas has been ploughed under in early July and the other when the crop is in full bloom, which comes usually toward the latter part of July. The tares are also ploughed under in late July. The barnyard manure is applied in September and disked in. The average results for nine seasons have been as follows:—

GREEN MANURING, 1913–22

Treatment	Average yield of wheat for nine years	
	bush.	lbs.
Peas ploughed under early July	34	51
Peas ploughed under when in full bloom	32	40
Tares, ploughed under late July	30	18
Bare fallow average of two plots	36	20
Bare fallow with barnyard manure	37	38

It will be observed that in both tests the effect of the green crops ploughed-in has been to depress the yield of wheat in the next season. The explanation of this would appear to be that moisture is a more important factor in wheat production than fertility. While the crops turned under must add humus and nitrogen to the soil, the moisture which they remove in making their growth is more likely to be scarce, under the conditions prevailing here, than these elements of plant food. The fact that the peas which are ploughed early have depressed the yield less than those ploughed at a later date is further evidence that it is the amount of moisture used before ploughing that has determined the yield.

While the continuation of successful crop growing in Manitoba will require the return of vegetable matter to the soil, this experiment would appear to indicate that the growing of crops for manure on the summer-fallow land is not the best way to accomplish this end. Success in other experiments in the growing of leguminous hay crops, and the development of crop rotations including them, would suggest that these form a more promising method of accomplishing the desired end. To grow the crop for manure alone is an expense that is hardly justified under present conditions. But if a crop such as alfalfa or sweet clover can be grown for its own economic value as a crop and the manurial effect accomplished as a by-product, the desired result is accomplished in a much cheaper way.

From 1923 on, this experiment is being continued in a different way. One plot is being sown to sweet clover in the crop of oats preceding the fallow. Then the sweet clover is ploughed in at the same time as the regular summer-fallow ploughing. This obviates the late ploughing necessary when spring sown crops are ploughed in. The old experiment will be continued except that the tares are dropped.

FERTILIZING EFFECT OF CLOVER

On two occasions when ranges of grass and clover plots have been ploughed up, wheat has been sown the following year and the yields have given data on the fertilizing effect of clover.

YIELDS OF WHEAT IN 1911

Crop Sequence	Yield per acre	
	bush.	lbs.
Wheat following red clover	37	5
Wheat following alsike	33	30
Wheat following western rye grass	27	37
Wheat following timothy	26	47

YIELDS OF WHEAT, 1915

Crop Sequence	Yield per acre	
	bush.	lbs.
Wheat following alfalfa (average of eight plots)	61	10
Wheat following red clover	58	30
Wheat following alsike	57	40
Wheat following western rye grass	49	40
Wheat following red top	47	20
Wheat following timothy	43	60
Wheat following Kentucky blue grass	38	..
Wheat following brome grass	29	20

Both these tests show quite clearly that the plants of the legume family leave the soil in richer condition than do the grass crops, and that larger crops of wheat follow as a result.

COMMERCIAL FERTILIZERS

A test of the use of commercial fertilizers in the growing of wheat was conducted in the years from 1900 to 1906. Nitrate of soda in two different quantities per acre, muriate of potash, superphosphate and a mixture of all three were tried out. The soil used was summer-fallowed the previous year. The fertilizers were applied as indicated in the following table. The results obtained in the average of six years are as follows:—

COMMERCIAL FERTILIZERS

Fertilizers applied	Average yield of wheat per acre, six years	
	bush.	lbs.
Nitrate of soda, 100 pounds per acre, one-half sprinkled on when grain is 2 inches high, balance when 6 inches high	33	10
Nitrate of soda, 200 pounds per acre applied as above	34	3
No fertilizer	31	53
Superphosphate, 400 pounds per acre, spread just before sowing	33	27
Muriate of potash, 200 pounds per acre, spread just before sowing	36	18
Superphosphate 200 pounds Nitrate of soda 100 pounds Muriate of potash 100 pounds — One-half spread before sowing, balance when crop is 2 inches or 3 inches high.	38	10

A somewhat similar experiment has been conducted from 1913 to 1923. In this case the experiment has been operated in a four-year rotation in a single set of plots, wheat coming once in the four years. The fertilizer was applied

at the time of seeding the corn crop, the wheat followed after the corn and was therefore one year later than the time of application of the fertilizer. In this test, wheat was grown in 1915, 1919 and 1923. The following results were obtained:—

COMMERCIAL FERTILIZERS

Fertilizer applied	Average yield of wheat for three years	
	bush.	lbs.
Nitrate of soda, 160 lbs. per acre	29	30
Superphosphate, 300 lbs. per acre	30	3
Muriate of potash, 100 lbs. per acre	28	13
Nitrate of soda, 160 lbs. Superphosphate, 300 lbs. per acre Muriate of potash, 100 lbs.	33	..
Nitrate of soda, 160 lbs. per acre Superphosphate, 300 lbs.	32	23
Nitrate of soda, 160 lbs. per acre Muriate of potash, 100 lbs.	30	7
Superphosphate, 300 lbs. per acre Muriate of potash, 100 lbs.	27	13
Basic slag, 500 lbs. per acre	28	37
Barnyard manure, 8 tons per acre	30	33
Barnyard manure, 16 tons per acre	31	33
No fertilizer (average of six check plots)	29	51

While in certain instances in the above tests some increases in yields have resulted from the use of commercial fertilizers, especially from the combination of the three kinds, yet the increased yields have not in any case been sufficient to justify the heavy outlay necessary for the purchase of fertilizer and the cost of application.

Manitoba soils are normally well supplied with the elements of fertility. With reasonably good systems of cropping the use of fertilizers should not be required for a great many years. There are some soils deficient in certain constituents which will therefore require fertilizers, but these are practically unknown on the prairies.

ROTATION OF CROPS

EARLY ROTATIONS

The work of experimenting with crop rotations has occupied an important place on the Farm at Brandon, for many years.

In the spring of 1899, arrangements were made for a series of rotation plots, the principal object being the maintaining of the fertility of the soil by the ploughing under of a leguminous crop every third year in place of the usual summer-fallow.

As the first field selected was flooded in 1902 and 1904, it was found unsuitable and a new location was selected in 1905. Again in this test only rotations of three-year duration were tested and the comparison was really between the bare summer-fallow and the ploughing in of legmuinous crops. No other crops than grain were harvested and no cultivated crops introduced. The test was continued five years (until 1909). The crops harvested were valued as follows: wheat, 90 cents per bushel; oats, 40 cents per bushel; barley, 50 cents per bushel. The rotations included in the test and the value of total crop per acre harvested in the five years are as follows:—

ROTATION TEST

Rotation	Value of total crop per acre in five years
	$ cts.
Wheat, wheat, peas, average of three replications	95 16
Wheat, oats, tares, average of three replications	108 31
Wheat, wheat, red clover, average of three replications	97 34
Wheat, barley, alfalfa and alsike, average of three replications	87 20
Wheat, wheat, summer-fallow	117 37
Wheat, oats, summer-fallow	115 47
Wheat, barley, summer-fallow	103 05
Wheat, wheat, oats	143 62
Wheat, oats, barley	130 45

It will be observed that the continuous growing of grain crops has out-yielded the grain and summer-fallow, while the latter has in turn done better than the ploughing in of green crops. However, so far as continuous grain growing is concerned, practical experience has amply demonstrated that it is not a success even though good returns may have been obtained for the first few years on well-cultivated lands.

The comparison of the ploughing-in of grain crops with bare summer-fallow is corroborative of the results in another experiment reported elsewhere and leads to the conclusion that this is not the most practical method of coping with the problems connected with crop rotation.

ROTATIONS TESTED, 1912-21

In 1910 an experiment in crop rotations on an entirely different scale was undertaken. In launching this new experiment, Mr. Jas. Murray, who was Superintendent at that time, made the following statement:—

"Since its settlement thirty years ago, Manitoba has been known as a grain-producing province. The virgin condition of the prairie permitted the land to be brought under cultivation at little expense, and the acreage in cereals increased rapidly. A soil more than usually rich in plant food and a climate particularly suitable enabled more grain growing to be continued for many years at a profit.

"An abundance of hay in sloughs and on unoccupied land rendered unnecessary the cultivation of hay crops, and, as little stock was kept, pasture was easily secured. The bulk of the land held by every farmer was therefore available for grain growing.

"When the soil was new, manure was not required. Later, when it should have had a good effect, a too liberal application often had a deleterious instead of a beneficial result on account of the soil being dried out. The use of manure was, therefore, in many cases abandoned.

"The control of weeds was from the first one of the problems which annually pressed for solution. The summer-fallow was most generally used for this purpose, and in the case of most weeds with good results. Good crops, comparatively free from weeds, usually succeeded the fallow for a few years. When weeds again became numerous the same remedy was applied.

"This system of farming has in large measure been continued up to the present, although of late years there has been a tendency on the part of some farmers to adopt other systems. For this change there are several causes. The continual removal of grain crops from the land with nothing added to counter-

act the loss of essential elements of plant food, has resulted in the soil being gradually impoverished and less able to produce abundant crops. The continued cultivation and the exposure of the soil to the sun and air by summer-fallowing has had the effect of working the fibre out of the soil and depleting the humus, thus making it more liable to blow, more difficult to work, and less congenial to growing plants. The incursions of weeds of various kinds not easily destroyed by summer-fallowing have also had the effect of directing attention to a more diversified system of farming.

"The effect of continuous grain growing with little or nothing being returned to the soil must become more marked from year to year. The length of time that it can be continued profitably depends on various factors, chief among which are the nature of the soil, its virgin store of plant food and the thoroughness of cultivation from year to year.

"A rich clay soil is capable of producing, when handled to best advantage, many more crops than a light soil, but the most productive must ultimately fail to be profitable when no return is made to it to counterbalance the constant drain of fertility through the removal of grain crops.

"A solution of the problem lies in the adoption of a system of crop rotation that will gradually year by year make the land more productive and at the same time enable the margin of profit to be increased.

"A crop rotation is simply an arrangement of the various farm crops which repeats itself each time the course is run. A rotation may be of any number of years' duration, but most rotations are of less than ten years.

"The kind of rotation that should be adopted on any given farm will depend on the class of farming followed, and the nature of the soil. In arranging a rotation, a knowledge of the food requirements of the various kinds of crops is essential in order that they may succeed one another to the best advantage. For example, such crops as corn, roots and hay require an abundance of nitrates for building stem and leaf and can therefore make excellent use of manure, whereas cereal crops can do with less nitrates and may follow a corn or root crop. The planning of the rotation resolves itself into arranging the three classes of crops, cereals, grass and hay crops, and cultivated crops to the best advantage for the system of farming followed, and to suit the particular farm.

"Since cereal farming is bound to be the chief branch of farming in Manitoba for many years yet, it follows that rotations suitable for adoption here must provide for a considerable acreage in grains. The proportion of pasture, hay and cultivated crops will depend upon the amount of stock to be provided for. On some farms there is sufficient rough land for pasture, and on such a farm no provision requires to be made in the regular rotation for a pasture crop.

"Just what rotations are suited to conditions in this province is as yet an unsettled question, but one which is deserving of close study. In order to get some definite information a start was made some years ago in putting a number of rotations into practice on parts of this Farm and now most of the cultivated land has been put under one or other of a number of test rotations."

Eight rotations were laid out at the time referred to. These were planned to compare straight grain growing with mixed farming, the latter rotations to include hay crops and hoed crops in various combinations. They were laid out in field areas so as to have actual farm conditions as nearly as possible and to allow for accurate cost accounting in the production of the crops.

This experiment continued until 1921. The floods of 1922 and 1923 which submerged the land used for this purpose have interrupted the work.

During the first few years some modifications were made, but for a number of years previous to 1921, the rotations were carried on in a uniform manner.

The rotations under test, the methods of operation, and the comments on the results are included in the following excerpt from the 1921 annual report of the Farm:—

"Rotation 'E' (Four Years' Duration)

First year—Wheat.
Second year—Wheat.
Third year—Oats.
Fourth year—Summer-fallow.

"This rotation represents typical Manitoba grain farming at its best. Four fields of three and one-half acres each are used for it; the soil ranges from sandy loam to heavy clay loam. The wheat of the first year is sown on summer-fallowed land. After the crop is removed, the land is fall ploughed; after proper preparation in the spring it is sown to wheat again. This wheat stubble is ploughed in either spring or fall and the third crop is oats. The fourth year the land is ploughed fairly deep in June and kept clean by repeated cultivation with the broadshared cultivator during the summer and fall. This rotation gave good results in the early days in grain growing, as it systematized the arrangement of crops, and the summer-fallow once in four years conserved moisture and gave an opportunity to fight weeds. However, it makes no provision for the return of fertility or vegetable fibre to the soil, and the summer-fallow once in four years is found to be an inadequate means of keeping annual weeds, such as wild oats and stinkweed, in check. Three crops of grain in succession give these weeds a great chance to multiply and many of the weeds refuse to germinate in the season of summer-fallow, especially if it is dry. The menace of soil blowing is almost a certain accompaniment to this rotation.

"Rotation 'D' (Four Years' Duration)

First year—Wheat.
Second year—Wheat (Manured).
Third year—Oats.
Fourth year—Summer-fallow.

"This rotation is exactly the same as 'E' so far as sequence of crop and method of cultivation are concerned, the only difference being the application of manure once in the four years. It occupies fields of the same size as those of 'E' and contiguous and alternate to them. The manure is applied in the fall after the removal of the first crop of wheat and is ploughed under in preparation for the second crop.

"During the first years, the increased return from the manure was not sufficient to pay for the cost of application. In 1920 and 1921, while both rotations were operated at a loss, the loss was less on the manured land, showing that the time has now apparently come with this land when the application of manure is needed and will be paid for in increased returns.

"Rotation 'H' (Six Years' Duration)

First year—Wheat.
Second year—Oats.
Third year—Summer-fallow.
Fourth year—Wheat, seeded with grass and clover.
Fifth year—Hay.
Sixth year—Hay or pasture, manured and broken in midsummer.

"This rotation represents a mixed farming system which includes the growing of sod-forming and leguminous hay crops as well as grains and thus provides for the return of vegetable fibre and fertility to the soil.

"Six fields of nine acres each are used for this rotation. The land is heavy clay loam and when first allotted to the rotation was badly infested with couch grass. This area was at first divided into two rotations: 'H' and 'I,' of somewhat similar character, but with flax on breaking on 'I.' However, the best features of both have been combined in 'H' as stated above.

"The wheat of the first year is sown on the sod land which has been broken up, manured and cultivated the previous year. After this crop is taken off the land is ploughed, either in spring or fall, and sown the next year to oats. The third year the land is summer-fallowed. Owing to the presence of couch grass, two ploughings have been given and thorough cultivation in addition, with the result that the couch grass has been practically all cleaned out. The next year wheat is sown on the summer-fallowed land and with it a mixture of grass and clover. The next year hay is cut and after haying the field is pastured. The last year the field is pastured until about July 15, then ploughed shallow, manured, and later backset and worked up in preparation for the wheat of the first year. This handling of the sod land has helped to clean up the couch grass.

"This rotation is giving very satisfactory results. The seeding down on the summer-fallow gives the grasses the best possible chance to catch. One-third of the land is in wheat and it is all on either summer-fallow or well-prepared breaking so that failure is very unlikely. There are never more than two grain crops in succession and there are two opportunities for cleaning weeds (summer-fallow and sod breaking) in the six years. This rotation is well suited to wide adoption in Manitoba. In practice, part of the summer-fallow might well be planted with corn.

"Rotation 'F' (Five Years' Duration)

First year—Wheat.
Second year—Wheat.
Third year—Corn (manured previous fall).
Fourth year—Oats or barley (seeded with grass and clover).
Fifth year—Hay.

"This rotation adds corn to the crops included. It is a mixed farming rotation which provides for the production of a large amount of fodder for live stock, and also has two-fifths of the land in wheat. It makes no provision for pasture and is suited only to farms where the pasture requirements are met by a sufficient area or permanent pasture land.

"Five fields of eight and one-half acres are used for this rotation. The land is black loam, mostly heavy, with a light ridge across the fields. The wheat of the first year is sown on sod land ploughed in midsummer and worked up during the fall. The land is fall-ploughed after the crop is removed and sown to wheat again the next year. After the second crop of wheat is taken off, the land is manured in the fall and fall-ploughed in preparation for corn. Corn is used as a substitute for summer-fallow and is kept thoroughly cultivated in order to prevent weeds from going to seed. The next year, oats or barley is sown on the corn stubble without ploughing and, with these, grass and clover seed. The fifth year a crop of hay is cut and, immediately after haying, the land is ploughed and prepared for wheat again.

"This rotation has given very satisfactory results. The corn is a much cheaper means of cleaning the land than summer-fallow, as it gives a crop of valuable fodder instead of an idle year. The wheat grown on the hay land is not usually quite as heavy a crop as it would be on summer-fallow but it is more

cheaply produced. The seeding sown on corn land gives the grasses a good chance. The area of corn is too large for actual farm practice in Manitoba, but this could be easily modified by having part of the field in summer-fallow or, in moist districts, in green feed.

"Rotation 'G' (Six Years' Duration)

First year—Wheat.
Second year—Wheat.
Third year—Oats or barley, seeded with grass and clover.
Fourth Year—Hay.
Fifth year—Hay or pasture, ploughed and manured in midsummer.
Sixth year—Corn.

"This rotation is similar to 'F' in the crops that it includes, but is somewhat different in arrangement and adds a year of grass, making it one year longer.

"Six fields of six acres each provides the land required for this rotation. The soil is heavy clay loam. The wheat of the first year is sown on corn stubble land without ploughing. After this crop is taken off, the land is fall-ploughed and again sown to wheat. After the second crop of wheat the land is ploughed in either fall or spring and sown to oats or barley with grass and clover seed. The next year hay is cut and, the aftermath used for pasture. The fifth year the land is pastured until July, when it is manured, ploughed and prepared for corn the next year.

"This rotation has given very satisfactory results. The wheat on corn land is the highest yielding and most profitable wheat on the Farm practically every year. The corn on sod land is also in a very favourable position and averages a good return.

"The weakness of this rotation is the seeding down with the third crop of grain which puts the grasses in an unfavourable position and makes failures frequent in obtaining a catch. When the grass fails, fall rye has been used as a substitute, being sown in the fall, and cut for hay, then a second seeding being sown for fall and early summer pasture. This rotation has produced greater profits than either 'H' or 'F' but it is rather more difficult to control weeds in it on account of the three years of grain in succession and the difficulty of getting a catch of grass. It is well suited to moist districts where grasses catch readily and where three crops of grain in succession can be grown successfully. As in the case of 'F' the area of corn is too large for Manitoba farm practice and part would have to be used as fallow in actual farm use.

"Rotation 'W' (Ten Years' Duration)

First year—Wheat.
Second year—Wheat.
Third year—Corn (manured).
Fourth year—Oats.
Fifth year—Barley.
Sixth year—Alfalfa sown without nurse crop.
Seventh year—Alfalfa.
Eighth year—Alfalfa.
Ninth year—Alfalfa.
Tenth year—Alfalfa ploughed up after first cutting.

"This rotation features alfalfa as the main crop. Alfalfa being rather expensive to start and requiring several years to give its full returns, needs a long rotation. The rotation is adapted to a pure-bred live stock or dairy farm where a large amount of high-class fodder is acceptable.

"There are ten fields allotted to this rotation; they are of the same width but of varying area (from 1.4 to 2.9 acres). The soil is heavy clay loam. The wheat of the first year is sown on alfalfa land which has been broken early the previous year, backset and worked up into good tilth. After the first crop of wheat is taken off, the land is fall-ploughed and in the spring sown to wheat again. The next fall, manure is applied and ploughed in. The third year corn is planted and cultivation is conducted so as to make it a substitute for summer-fallow. Oats are sown the following year on the corn stubble land without ploughing. After the oats the land is fall-ploughed and sown in the spring, as early as it is safe, to barley. The land is ploughed early in August as soon as the barley is cut and before stooking, so as to make conditions favourable for sowing alfalfa the next year. The alfalfa is sown without a nurse crop and no crop is obtained that year. The next three years, alfalfa hay is cut twice a year and the last year one cutting is taken off about the last of June and the land is then ploughed and afterwards backset and worked up in preparation for wheat.

"This rotation has operated very successfully here and gives the largest returns and profits of any of the rotations under test. Where alfalfa is grown successfully and where the type of live-stock farming which it represents is chosen, this rotation can be depended on to be a money maker.

"Rotation 'Q' (Eight Years' Duration)

First year—Roots and Peas.
Second year—Wheat or oats (seeded with grass and clover).
Third year—Hay.
Fourth year—Hay.
Fifth year—Pasture.
Sixth year—Pasture.
Seventh year—Pasture (ploughed up in midsummer).
Eighth year—Green feed and rape (manured in fall).

" This rotation is located on light sandy and gravelly land and is intended to represent a sheep farm. Eight fields of five acres each are used.

"The first year calls for peas and roots, sown on land that grew green feed and rape the previous year. In practice it is found impracticable to grow roots in this way and peas only have been used. The second year, oats are sown and with them a mixture of grasses and clovers suitable for a long period of hay and pasture. The next two years, hay is cut and the three following years the land is in pasture. In the last of these years (the seventh of the rotation) the sod is ploughed early in the summer and backset if necessary and prepared for grain crop. The last year about an acre is sown to rape and after this is fit for use the temporary fence which is used is moved so as to include it with the pasture. The rest of the field is sown with rye or oats for green feed.

"This rotation has not given satisfactory results. There is not sufficient conservation of moisture for this light land on which an occasional summer-fallow is necessary. Also, the seeding down is disadvantageously placed and poor catches or failures are frequent. The grass remains too long before breaking up and gets sod bound and unproductive."

The above rotation " Q " was discontinued in 1920 and the following was inaugurated in its place as more suitable for a light-land rotation.

Rotation "Q" (Eight Year's Duration)

First year—Corn (manured) and summer-fallow.
Second year—Wheat seeded with grass and clover.
Third year—Hay.
Four year—Pasture.
Fifth year—Fallow (breaking up sod).
Sixth year—Wheat (manured).
Seventh year—Oats.
Eighth year—Annual pasture crops.

This rotation has three years out of eight in grain crops, the two crops of wheat being placed in the most favourable positions. It includes grass and clover for the control of soil conditions, and corn, hay and pasture for live stock.

Eight fields of five acres each are used for this rotation. The land is a light, gravelly, sandy loam and is not at all similar to the soil upon which the other rotations are located. The results will therefore not be comparable but will have to be considered by themselves. This rotation is so arranged as to make it possible to fence the eight fields in four enclosures, thus reducing the division fences by half. Years one and five are enclosed together, two and six together and so on.

The first year may be fallow or corn or part of each; if corn, manure is applied the previous fall, and in either case the land is well cultivated so as to be suitable for wheat next year. The second year wheat is sown, and with it a mixture of brome grass and sweet clover. The third year hay is cut, and in the fourth, the sod is pastured. A whole season is allowed for the breaking up of sod and the storing of moisture. Then the next year wheat is sown on the breaking; the next year oats follow on spring or fall-ploughed land; and the last year, oats, rye or rape or some of each, is grown for pasture.

The land allotted to this rotation has not been affected by the floods. It has operated successfully during the three years in which it has been getting started and promises to be of value, the crops grown last being longer than were formerly grown in this land under the old rotation. Longer trial will be necessary before definite results can be given.

From the start of these rotation experiments a fixed scale of values was used in calculating the cost of crop production and the value of the crop. These were based on average costs and values in the years around 1910 and 1911 when the work was inaugurated. Up till 1918 this scale was used in arriving at results in dollars and cents. By that time an entirely different scale of values had been brought about by the war and each year had widely different values from the last. Consequently, the old fixed scale was abandoned and a fresh scale drawn up for each season, based on prevailing prices in that particular season. The following show the average results obtained from 1914 to 1918 on the old scale values and the average results from 1919 to 1921 based on varying prices for each year.

ROTATIONS—FIVE-YEAR AVERAGES

The following average results from the rotations are those of the years 1914 to 1918, when pre-war valuations were still used as the basis of calculation:—

Rotation	Cost per acre	Revenue per acre	Profits per acre	Percentage profit on cost
	$ cts.	$ cts.	$ cts.	%
E	8 50	10 73	2 23	26·24
D	10 19	11 99	1 80	17·66
H (and I)	9 00	12 99	3 99	44·33
F	11 93	15 98	4 05	33·95
G	11 38	17 14	5 76	50·61
W	10 38	15 85	5 47	52·7
Q	7 17	7 26	0 09	1·26

ROTATIONS—(THREE-YEAR AVERAGES)

The following are the average costs, returns and profits from these rotations for the three years 1919 to 1921:—

Rotation	Average cost per acre	Average return per acre	Average profit per acre
	$ cts.	$ cts.	$ cts.
"E"	16 20	23 04	6 84
"D"	18 29	26 00	7 71
"H"	16 42	23 93	7 51
"F"	21 02	28 48	7 46
"G"	21 99	32 78	10 79
"W"	19 37	33 79	14 42

GENERAL OBSERVATIONS ON ROTATIONS

The rotation work for the eleven years, 1911-1921, has brought out some facts which may be worth special attention at this time.

One of the things proved by these rotations is that mixed farming can be made to bring in as good an immediate return from the land as grain growing, leaving out of reckoning entirely the consideration of the ultimate effect on the land. The average profit during the years before war prices for grain came in, was at least 50 per cent higher from the mixed-farming rotations than from rotation " E." This was due to the fact that though the area of wheat is less in the mixed farming rotations, the yields are higher, so that as much wheat is produced from less area, and the fodder crops are produced in addition.

Another outstanding feature is the great rotation value of corn. The first year of rotation " G " where wheat follows corn, has been the most satisfactory and profitable wheat on the farm. The wheat following corn is always good. Through good years, dry years, or rust years it never fails to produce a satisfactory crop. The flood is the only climatic factor that has ever prevented this crop from being a success.

The importance of putting the seeding-down to grasses and clovers in a favourable place in the rotation has been thoroughly proven during the dry years. Rotation "H," where the seeding-down takes place on summer-fallowed land, has had only one failure in ten years, while rotation " G," where the seeding is with the third crop of grain, has had four failures to catch in the same period.

When the rotations were first started, red clover was used as the clover in the hay mixture. In some wet seasons it grew satisfactorily, but in the drier seasons or severe winters it was not dependable. The great success of alfalfa in the other experiments led to trying it in the rotations and it is now used

in both "H" and "G" where the sod remains two years. It is giving much better results, standing frost successfully and withstanding drought better than any other crop grown. It starts successfully in a nurse crop of grain, notwithstanding the idea so generally held a few years ago that it must be sown alone in order to succeed. In rotation "Q" on the light land, sweet clover is now being used in the mixture along with brome grass. This mixture seems best for this type of soil.

COST OF PRODUCTION

The first table on the cost of production of wheat in the annual reports of this farm appears in the 1894 report. No further mention is made of cost of production until 1914 when the results of the rotation experiments in field areas made such figures available. These have been available yearly since that time. The table for summer-fallow production for 1894 and 1914 and 1923 are presented herewith, and the cost of production on wheat stubble land in 1923.

Cost of Growing Wheat on Summer-Fallow

1894

	Cost per acre $
Ploughing once	1.25
Harrowing twice at 10 cents	0.20
Cultivating twice at 20 cents	0·40
Seed 1½ bushels per acre at 50 cents	0.75
Drilling	0.22
Binding	0.33
Cord	0.20
Stooking	0.18
Stacking	0.60
Threshing (5 cents per bushel)	1.46
Teaming to market, 4 miles at 1 cent per bushel	0.29
Two years' rent or interest on land values, $15 at 6 per cent	1.80
Wear and tear of implements	0.20
Total cost per acre	7.88

Yield per acre, 29 bushels.
Cost per bushel, 26·7 cents.

1914

	Cost per acre $
Rent of land (two years)	4.00
Ploughing. Man and 4 horses, 3·33 hours at 48 cents	1.60
Packing. Man and 4 horses, 1·33 hours at 48 cents	0.64
Cultivating. Man and 4 horses, 6·55 hours at 48 cents	3.14
Harrowing. Man and 2 horses, 1 hour at 34 cents	1.36
Seeding. Man and 2 horses, 1 hour at 34 cents	0.34
Binding. Man and 3 horses, 1 hour at 41 cents	0.41
Stooking. Man, 1·11 hours at 19 cents	0.21
Threshing, 32·44 bushels at 7 cents per bushel	2.27
Use of machinery, 2 years at 60 cents per acre	1.20
Seed	1.50
Twine	0.77
Total cost per acre	17.44

Yield per acre, 32·44 bushels.
Cost per bushel, 53·8 cents.

1923

	Cost per acre $
Rent of land, 2 years at $4	8.00
Use of machinery, 2 years at $1	2.00
Seed, 1¾ bushels at $1.25	2.19
Teamster and four horses, 11·58 hours at 68 cents	7.89
2·86 hours ploughing	
5·72 hours cultivation of fallow	
0·58 hours cultivating in spring	
0·71 hours harrowing	
0·71 hours seeding	
1·0 hour cutting	
11·58 hours	
Manual labour stooking 1·43 hours at 30 cents	0.43
Threshing, 24·29 bushels at 15 cents	3.64
Twine	0.43
Total cost per acre	24.58

Yield per acre, 24·29 bushels.
Cost per bushel, $1.01

Cost of Growing Wheat on Stubble Land Fall Ploughed

1923

	Cost per acre $
Rent of land	4.00
Use of machinery	1.00
Manure, ¼ rd. store of 6 tons at $1.50	3.00
Seed, 1¾ bushels at $1.25	2.19
Teamster, and 4 horses, 5·57 hours at 68 cents	3.79
2·57 hours ploughing	
0·86 hours cultivating	
0·43 hours harrowing	
0·71 hours seeding	
1 hour cutting	
5·57 hours	
Manual labour stooking, 1·13 hours at 30 cents	0.34
Threshing, 19·43 bushels at 15 cents	2.91
Twine	0·25
Total cost per acre	17.48

Yield per acre, 19·43 bushels
Cost per bushel, 90 cents

PUBLICATIONS ON WHEAT

The following publications of the Department of Agriculture relating to wheat are available on application to the Publications Branch, Department of Agriculture, Ottawa:—

(Varieties, Cultural Practices, Etc.)

Crop rotation for dry farming districts of Canada.....Ex. Cir. 35
Preparing land for grain crops on the prairies.....Bul. 15 S.S.
Growing grain on the prairies.....Sp. Cir. 1, E.F.
The best varieties of grain.....Pamp. 11, N.S.
New varieties and selections of grain.....Bul. 11, N.S.
The rod cultivator.....Pamp. 28, E.F.
Seed cleaning.....Pamp. 4, N.S.

(Insects and Diseases)

Smut diseases.....Bul. 73, E.F.
Seed treatment for grain smut.....Ex. Cir. 24
The Hessian fly in the Prairie Provinces.....Pamp. 30, N.S.
The control of cutworms in the Prairie Provinces.....Cir. 6, E.B.
Locust and grasshopper control.....C.P.L. 6, E.B.

(General)

Annual reports of Dominion Experimental Farms in the Prairie Provinces.....
Flour and bread wheat researches.....Bul. 97, E.F.
Seeds Act, 1923, and Regulations.....A.O.R. 11.

OTTAWA: Printed by F. A. ACLAND, Printer to the King's Most Excellent Majesty, 1924.